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Computer-assisted dieting: Effects of a randomised controlled intervention

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In this pilot study, the effects of two computer-assisted dieting (CAD) interventions on weight loss and blood chemistry were examined among overweight and obese adults. Participants (91 community members, average age 42.6 years) were randomly assigned to CAD-only (a single-session introduction and provision of a dieting software, $n = 30$), CAD plus an additional four-session self-management group training (CAD+G, $n = 31$) and a waitlist control group whose members were randomised into the two interventions at the 3-month follow-up ($n = 30$). A three (group)-by-two (time) repeated measures ANOVA revealed no significant group by time interaction during the initial 3-month period. However, the two intervention groups combined showed a significant, though moderate weight loss relative to the control group. Further, although a general improvement was found with regard to the lipid panel results during the first 3 months of the trial, the treatment by time interaction was not significant. A comparison of the developments in the two intervention groups during the 3- to 6-month follow-up time period revealed a tendency towards greater weight regain in the CAD-only condition. The evidence suggests that CAD supports initial weight loss; however, additional self-management training might be necessary to support maintenance.

Keywords: obesity; intervention; weight loss; self-management; RCT

Introduction

The latest data from the National Center for Health Statistics indicate that 32.2% of US adults are obese with a body mass index (BMI) ≥ 30, and an additional 34% are overweight with a BMI between 25 and 29.9 (NCHS, 2006). This translates into an estimate of about 136 million adults in the US who are either overweight or obese and, thus, at increased risk for a number of weight-related and highly prevalent health conditions including hypertension, dyslipidemia, diabetes, cardiovascular disease, stroke, osteoarthritis and certain types of cancer (AHA, 2006; CDC, 2006; NIH, 1998).

Obesity and related health risks are strongly affected by common behavioural factors involving unhealthy eating habits combined with a sedentary lifestyle. Thus, a healthy lifestyle appears to be the primary answer to obesity and its associated health complications (NIH, 1998). With regard to dieting, the recommendations include

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a balanced diet that is low in fat and cholesterol, high in fibre, and limited in calories (NIH, 1998; USDA & USHS, 2000). In terms of behaviour change, these recommendations translate primarily into a reduction of added fats, oils and sweets, a reduction of animal products high in saturated fats, and an increase in vegetable and fruit consumption to a minimum of five servings per day (USDA & USHS, 2000).

Both nutrition education and weight loss interventions would gain much by an inclusion of objective physiological indicators of improved dietary habits such as lipid panel and blood glucose results. Among nutrition intervention trials, only about one-third of the studies include any physiological health outcomes (Contento, Randell, & Basch, 2002). Further, hardly any nutrition intervention study includes the full range of outcome measures, including weight, and further indicators of improved health.

Given the limitations of the existing research, the current study was designed to test the effects of two brief, computer-assisted dieting (CAD) interventions on weight loss and related physiological health outcomes among overweight and obese adults. Both interventions featured a brief, educational component in a group setting, which introduced participants to the mutual goal of weight loss combined with a balanced diet as defined by the US Department of Agriculture (USDA & USHS, 2000). Both interventions focused on self-management as the primary target and, thus, addressed individuals in advanced stages of change who are self-motivated and ready to start a dieting program (Prochaska, Zabinski, Calfas, Sallis, & Patrick, 2000). Volition theory (Heckhausen, 1991; Kuhl, 1985; Schwarzer, 2002) and the literature on self-management therapy (Kanfer, Gaelick-Buys, Kanfer, & Goldstein, 1991; Kanfer, Reinecker, & Schmelzer, 2005) provided the theoretical background of the interventions. Seen from a process perspective, the interventions focused on the post-intentional, volitional stage of behaviour change (Schwarzer, 2002), which are governed by different cognitive processes than the pre-intentional, motivational stage (Schwarzer, 2008). The theory holds that, once the decision-making process is completed and a goal intention has been built, the focus of attention needs to switch from deliberation to implementation, enactment and maintenance of behaviour (Gollwitzer & Bayer, 1999). The volitional phase typically involves planning, self-monitoring, self-evaluation, coping with failure, and similar self-management and self-control strategies, specifically if the behaviour in question is difficult to enact and long-term behaviour change is the target (Schroder & Schwarzer, 2005).

Theories of volition and self-regulation emphasise a number of processes as important mediators of successful goal pursuit. For example, inducing participants to build implementation intentions (i.e. intentions to engage in goal-directed actions) has been found to facilitate enactment and goal achievement (Gollwitzer & Brandstaetter, 1997). Further, theories of self-regulation point to the self-monitoring of behaviour as an indispensable part of successful goal pursuit (Kanfer et al., 1991). Self-monitoring has been found to play an important role in the successful self-management of dieting behaviour (Atkins, Depper, Poore, DiLaura, & Djuric, 2005; Glanz, Murphy, Moylan, Evensen, & Curb, 2006; Helsel, Jakicic, & Otto, 2007; Yon, Johnson, Harvey-Berino, Gold, & Howard, 2007). While self-monitoring of nutrition intake is commonly regarded as a core component of a successful dieting intervention, it is unlikely to lead to long-term success in isolation. It needs to be complemented with further self-management strategies such as self-evaluation and self-reward and the management of specific challenges such as temptation, craving and the social components of preparing and sharing food (Kanfer et al., 1991, 2005; Kuhl, 1985). In addition, the maintenance of a healthy and weight-conscious diet requires more than a short-term control of behaviour.

It requires the permanent, habitual control of food consumption (Schroder & Schwarzer, 2005).

Based on these considerations, a pilot study was conducted testing the effects of a CAD intervention, which focused primarily on the self-monitoring of nutrition intake, to a treatment condition that combined CAD with a more general self-management training, and to a no-treatment control group. The following hypotheses were tested:

(1) A brief CAD intervention will support initial weight loss relative to a no-treatment waitlist control condition.
(2) Compared to a CAD-only condition, CAD augmented with a self-management group (CAD+G) intervention will further enhance its effectiveness and improve the maintenance of weight loss over a longer period of time.

Method

Design

The study featured a three-group randomised controlled design (including two intervention and one waitlist control group) and three assessment points (four for control group members), scheduled in 3-month intervals (Figure 1). One intervention group was introduced to CAD only. The second group received CAD plus a 4-week group intervention targeting self-management skills (CAD+G). Both intervention groups were re-assessed 3 and 6 months following the initial assessment. A no-treatment control group was followed for the first 3 months only. After completing the first follow-up assessment, approximately 3 months after entering the study, control group participants were randomised into the two treatment conditions (CAD-only or CAD+G) and received treatment. Control group members were re-assessed 3 and 6 months later (Figure 1). Three-month assessment intervals were chosen to allow for sufficient time to observe any systematic changes in weight loss and blood chemistry as a result of dietary change. The primary outcome of interest was weight loss. Lipid panel analyses served as secondary outcomes. Data were collected between September 2004 and July 2005.

Participants

Community members of a mid-size town in the Rocky Mountain region of the US were recruited through announcements in local newspapers and radio stations. Eligibility criteria were (a) being aged 18–65 years; (b) having a BMI ≥ 27; (c) being interested in pursuing weight loss; (d) not being diagnosed with diabetes, hypercholesterol or a mental disorder and (e) having daily access to a personal computer. Recruits were invited to contact the research team in order to receive further information about the interventions and to determine additional eligibility criteria, which included: (1) willingness to accept random group assignment; (2) not being enrolled in an alternative weight loss program; (3) sufficient English-language proficiency; (4) having no friend or relative already enrolled in the study, and (5) being in the possession or having ready access to a personal computer with the following specifications: a Windows operating system compatible with the software; internet connection and a valid email account. Given budget restrictions, the maximum sample size was determined as approximately $n = 90$.

Ninety-four participants who contacted the study team by phone appeared to be eligible, accepted the terms of the study and were invited to an initial assessment session at

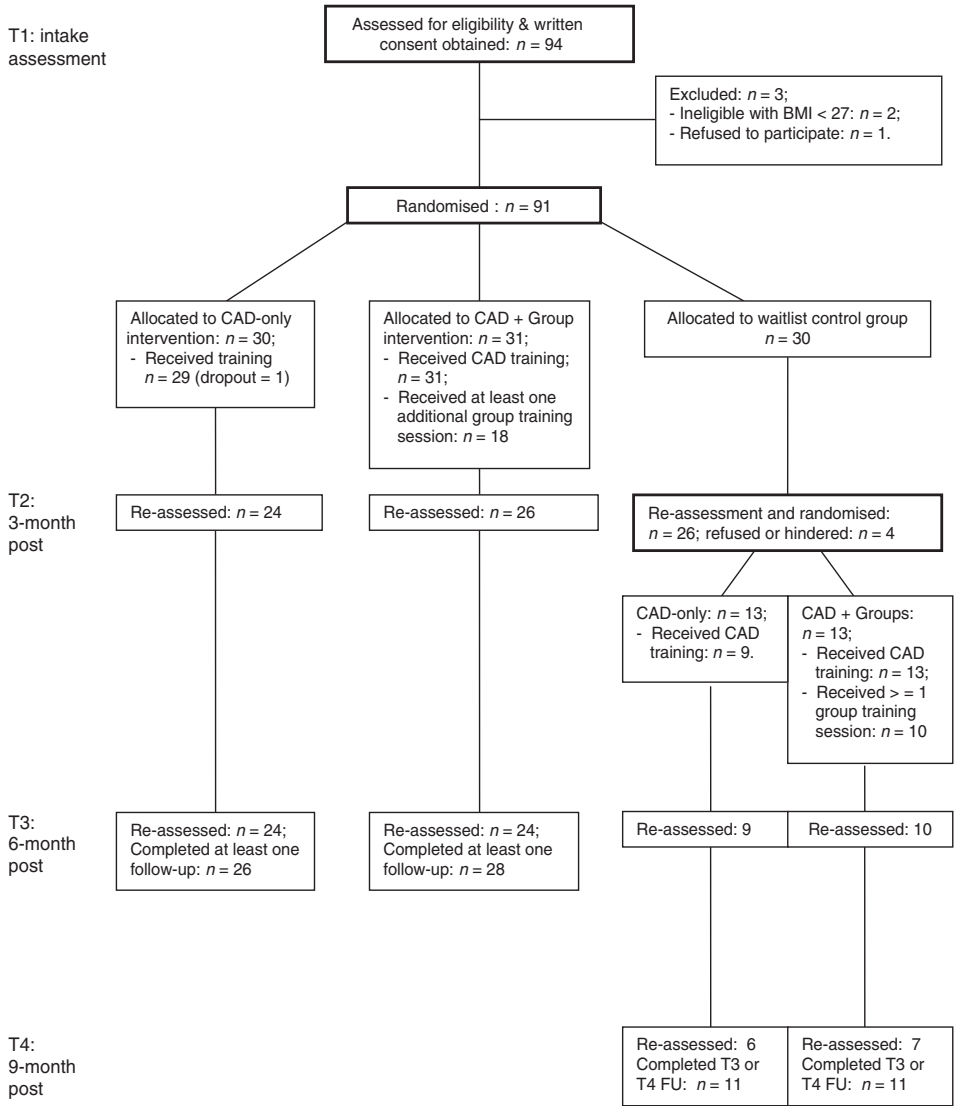

Figure 1. Participant flow.

the local psychology community clinic. Two of the 94 participants were found to be ineligible with a BMI < 27, and one participant decided on an alternative weight loss program. The final sample included 91 participants, 77 women and 14 men who were randomly assigned to the three treatment groups, separately by gender. Thirty participants (26 women, 4 men) were assigned to the CAD intervention; thirty-one participants (26 women, 5 men) were randomised into the CAD+G intervention; and 30 participants (25 women, 5 men) were allocated to the waitlist control group. Participants had an average age of 42.6 years (SD = 10.7) and $M = 14.8$ years of education (SD = 2.01). All except five participants were Caucasian. The average monthly household income of participants was \$3,758 (SD = 2304.3). On average, participants had 2.86 children (SD = 2.4) and 1.49 under-age children living at home (SD = 1.698). The mean BMI at intake was 34.6

(SD = 5.4). Eighteen participants (19.8%) were single, 64 (70.3%) were married and nine (9.9%) were divorced. No significant differences between the three treatment groups were found in these demographic variables.

Measures

Primary outcome measure: BMI

Primary outcomes were weight in pounds and body mass index calculated as BMI = [weight in pounds/(height in inches)^2] * 703. Weight was assessed in 3-month intervals, once before the intervention and again 3 and 6 months later.

Secondary outcome measures: lipid panel results

Blood samples were analysed using the CardioChek PA Analyser, a highly reliable blood testing device cleared both for professional medical users and home testing, which provides lipid panel results from a single drop of blood. Lipid panel results provided information about total blood cholesterol, HDL, LDL, cholesterol ratio (i.e. the ratio of total cholesterol to HDL) and triglycerides. Total cholesterol, cholesterol ratio and triglycerides were included as non-redundant secondary outcome measures and objective indicators of dietary change. All physiological measures were obtained in 3-months interval (Figure 1). Participants were asked to come in fasting (i.e. with no food or beverage intake during the past 12 h prior to the assessment sessions).

Procedure

All procedures were approved by the Institutional Review Board at Utah State University.

Preintervention assessment

During the initial phone contact, participants meeting the eligibility criteria were invited to an initial assessment session. In this session, all study procedures were explained in detail and written consent was obtained. Participants were informed that their personal information would be kept confidential, and that their data would be filed with a random personal identification code only.

During the physical exam, height and weight were assessed, and based on this information, the BMI was calculated. Subsequently, blood samples were analysed deriving lipid panel results from a single drop of blood. Participant were informed about the test results and advised to discuss the results with their family physician upon their next visit if any deviations from normal levels were found.

Once physiological data were collected, participants were led to a separate lab room where they completed the pre-intervention surveys. Upon return of the study materials to the research team, participants received a check of $20 as compensation for their time and expenses.

Randomisation

Randomisation took place following the initial assessment session. Participants were randomly assigned to CAD+G, CAD-only and control groups by the first author,

separately by gender, in the order of their entry into the study, with every third participant being assigned to CAD, CAD+G and control groups. Participants were informed by Email and phone about their group assignment, and those assigned to the two intervention groups were invited to a 2 h CAD training session. Control group members were informed that they would receive treatment 3 months later.

Interventions

CAD intervention. The single-session CAD intervention took place in groups at a university computer lab. The intervention was identical for members of both intervention groups. All research team members were blind with regard to the type of intervention assigned to the participants (i.e. whether or not they would receive additional self-management training). The intervention focused on (a) goal setting for weight loss and daily calorie consumption, and (b) self-monitoring of food intake and nutrition. It was based on elements emphasized in the literature on self-regulation and self-management therapy (Kanfer et al., 1991, 2005). Further, as an educational intervention, the session focused on dietary guidelines developed by the US Department of Agriculture (USDA, 1996).

The session was divided into three parts. In the first part, participants received general information about healthy nutrition as defined by the USDA food guide pyramid and the September 2002 guidelines issued by the US Institute of Medicine, which form the basis of the NutriGenie software. Particular emphasis was placed on the 'daily five' (i.e. the recommendation to consume a minimum of two servings of fruit and three servings of vegetables each day) and a reduction of servings from the 'fats and sweets' food group as the primary strategies to a healthy weight loss. Further, participants were introduced to the concept of 'recommended dietary allowances' (RDAs) and the need to define these for each individual separately. Using an LCD projector, the various functions of the NutriGenie software were explained. Participants were prepared to use the software as a feedback tool with the dual goal of reducing energy intake and keeping a balanced diet.

During the second part of the session, participants received training in the use of the software, including searching for food items in a database of more than 8000 entries, reading and interpreting the feedback portion of the screen, and identifying problem foods in their diet.

The third part of the session involved individualised goal setting with each participant separately. First, the participant's daily 'maintenance calories' were determined, based on current weight, gender, age and self-rated activity level. Next, the participant was guided towards a personal goal of reduced daily energy intake. The goal setting process started with the standard suggestions of one pound of weight loss per week, translating into a subtraction of 500 calories from the daily maintenance calories (or a savings of 3500 calories per week), which was then discussed with the participant and adjusted, if desired. Finally, participants were guided through the process of adjusting the software settings so that the RDAs displayed in NutriGenie would match their individual dietary goals. Participants were instructed to use the software daily and send – at a minimum – the first 7 days of NutriGenie food records by email to the research team.

CAD+G intervention. Following the CAD intervention session, participants randomly assigned to the CAD+G intervention were contacted again by Email and phone

to schedule a weekday and time for the self-management group intervention. The intervention took place in groups of three to seven participants who met over four consecutive weeks. In the CAD+G intervention, the self-management components targeted in the single-session CAD intervention (goal setting, self-monitoring) were supplemented with further self-management strategies, which were adopted from the self-management therapy (Kanfer et al., 2005), volition theory (Kuhl, 1985), and relapse prevention literature (Marlatt, 2001; Marlatt & Gordon, 1985). These strategies included behavioural (self-)contracts, self-reward, motivation control, environmental control and coping with lapses. Further elements informing the interventions, including information and skills training, were derived from the information-motivation-behavioural skills model (Fisher & Fisher, 1996).

Session 1 focused on information and discussions regarding the development of obesity in the US, causes of modern obesity and consequences of obesity on health. Following Weinstein's precaution adoption process model (Weinstein & Klein, 1996), health risks were personalised by estimating the risks of coronary heart disease, cancer and diabetes for volunteers from the group (relative to their normal-weight counterparts), based on their gender and BMI.

Session 2 focused on self-management skills and introduced participants to a variety of self-control strategies, which were practiced during and between subsequent sessions. Further, participants were introduced to the concept of 'implementation intentions' (Armitage, 2004; Gollwitzer & Brandstaetter, 1997), which were defined as precise behavioural plans that specify the time, circumstance or location, actions to be taken and criteria of success and failure. In an intention-building exercise, each participant was guided to form an implementation intention to be performed during the next 7 days.

Session 3 focused on maintenance and relapse prevention (Marlatt & Gordon, 1985) and included sections on problem diagnosis and problem-solving strategies. Participants were encouraged to view their dieting effort as a learning process that necessarily involves action slips and to adopt an 'action-oriented mind-set' (Gollwitzer & Brandstaetter, 1997) by focusing on problem-solving activities.

Session 4 was designed to discuss social and environmental influence on dieting success and dieting failure, consolidate relapse prevention skills, develop long-term dieting goals, and wrap up the content of the four sessions. With regard to relapse prevention, participants were taught to identify negative thoughts and to substitute efficient (action-oriented) for inefficient, demoralising attributions of lapse. The social component included a discussion of hospitality norms and social pressure to eat as well as effective strategies to deal with these barriers. Participants were encouraged to inform their social network about their dieting goals and solicit social support among their friends and relatives.

Skills training was consolidated through homework assignments between sessions, such as short-term self-control tasks, the development of clearly defined short- and long-term goals and a respective list of self-rewards to be applied upon successful completion.

Wait-list control group. No treatment was offered to participants assigned to the wait-list control group during the first 3 months. Upon completion of the second assessment session (Time 2, 3 months after the initial assessment session), returning participants ($n = 26$) were randomly assigned to one of the two interventions (CAD-only or CAD+G). The interventions applied to members of the waitlist-control group matched exactly the interventions applied to the original intervention groups.

Follow-up assessments

Participants in the CAD-only and CAD+G interventions were followed for a total of 6 months (i.e. completed two follow-ups in 3-month time intervals). The follow-up assessments involved all measures included in the initial assessment session (i.e. weight and BMI, physical exams including blood draws). For participants in the wait-list control group, an additional assessment session was scheduled 9 months after intake in order to retrieve a 6-month follow-up assessment since initiation of treatment. Each assessment session was reimbursed with $20.00; in addition, participants earned $10.00 for the return of the food diaries and $10.00 for the completion and Email submission of at least 7 days of food recording with the NutriGenie software, to be paid at their next appointment. In total, participants could earn up to $80.00 ($100.00 in the waitlist control group).

Data preparation and analysis

Data preparation

Two preparatory steps were performed. First, outlier values were replaced with the raw score corresponding to the limit value of $z = \pm 3$. Across all variables and assessment occasions, 27 outliers were identified (i.e. 1.15% of all scores). Second, in order to include participants who did not attend all of the follow-ups, missing data points were replaced with pre-intervention scores, applying a conservative approach to the testing of intervention effects.

Analyses

Test of Hypothesis 1. According to Hypothesis 1, CAD (with or without additional self-management intervention) should support initial weight loss. In order to test Hypothesis 1, a three (groups) by two (T1 vs. T2) repeated measures ANOVA was performed with BMI as the dependent variable. Both a priori and posteriori power analyses indicated limited test power for the crucial treatment by time interaction effect. An a priori power analysis performed with SPSS16, adopting data from Wylie-Rosett et al. (2001), indicated that a minimum sample size of approximately $N = 126$ (42 per group) would be needed to achieve a test power of 0.80 at $\alpha = 0.05$ assuming no weight change in a no-treatment control group and a weight reduction of 4.7 lbs and 7.4 lbs in the two treatment conditions. Therefore, the two treatment groups were combined to contrast weight loss in the intervention conditions against the control condition in a two (treatments vs. control) by-two (T1 vs. T2) post hoc ANOVA. In addition, alpha was set to 0.10 ($\alpha = 0.05$, one tailed) for tests of the group-by-time interactions. Given the strong overlap between weight and BMI ($r = 0.81$), only BMI was used in all but descriptive analyses.

Further, to test treatment effects on blood chemistry, a corresponding two (groups)-by-two (time) repeated measures MANOVA was performed with total cholesterol, cholesterol ratio and triglyceride counts as dependent variables. Univariate results were reported adjusting for familywise error rate (i.e. adjusting for the number of dependent variables included).

Significant group-by-time interactions were followed by simple repeated measures ANOVA *F*-tests, which tested change over time in treatment and control conditions separately. To control familywise error rate, tests of simple main effects adjusted the critical α-level for the number of possible simple main effects, following Dunn's procedure as described in Kirk (1995).

Tests of Hypothesis 2. In order to test Hypothesis 2, the two treatment conditions were compared across the entire sample to evaluate differential development in the CAD-only and the CAD+G interventions. For all physiological outcomes (BMI, lipid panels), the data of the waitlist control group participants were merged with the two intervention groups (CAD-only, CAD+G), according to the condition to which they were randomised at T2. In order to synchronize control group data with the three- and six-month follow up assessment points of the two original intervention groups, the T3 data of the control group members (marking their first follow-up) were merged with T2 data of the intervention groups; further, T4 data (which were collected in the control group only and established their 6-month follow-up) were merged with T3 data of the intervention groups.

To compare the maintenance of any initial treatment effects in the two treatment conditions over time, a two (CAD-only *vs.* CAD+G)-by-two (3-month *vs.* 6-month follow-up) repeated measures ANOVA was performed with BMI as dependent variable. Once again, a priori power analyses indicated a lack of test power. Assuming a weight regain of about 4.5 lbs in the CAD-only condition and no weight change in the CAD + G condition, a sample size of $n = 170$ (85 per group) would be needed to obtain a test power of 0.80 at $p < 0.05$ for the crucial group-by-time interaction. Accordingly, alpha was set to 0.10 ($\alpha = 0.85$ one tailed)

Further, a corresponding two (groups)-by-two (time) repeated measures MANOVA was performed with lipid panel results. Univariate results were reported adjusting for familywise error rate (i.e. adjusting for the number of dependent variables included). Simple effect ANOVAs were performed for the time factor, testing change over the 6-month period in the two intervention groups separately. Familywise error rate was adjusted by correcting the alpha level for multiple simple effects ANOVAs as recommended by Kirk (1995).

All analyses followed an intent-to-treat approach (Davidson et al., 2003), analyzing participants as members of the group to which they were randomly assigned, irrespective of whether they received the respective treatment. For all analyses effect size estimates in the population were calculated as partial ω^2.

Results

Change over time during the initial 3-month interval in treatment and control groups

Table 1 displays the means and standard deviations for the outcome variables by condition and assessment period. A three (group)-by-two (time) repeated measures ANOVA (not tabled) showed a significant effect of time only (Wilks' $\lambda = 0.778$, $F_{(1.88)} = 25.05$, $p < 0.001$). Although there was a tendency towards greater weight loss in both intervention groups relative to the control group during the first 3 months of the study, the group-by-time interaction was not significant (Wilks' $\lambda = 0.955$, $F_{(2.88)} = 2.07$, $p = 0.132$, $\omega_p^2 = 0.012$).

Given the fact that the two intervention groups showed almost identical treatment effects, and in order to improve test power, a *post hoc* analysis was performed, combining the two treatment conditions. A two (interventions *vs.* control)-by-two (T1 *vs.* T2) repeated measures ANOVA resulted in a highly significant change over time (Wilks' $\lambda = 0.844$, $F_{(1.89)} = 16.41$, $p < 0.001$, $\omega_p^2 = 0.087$) and a significant group-by-time interaction (Wilks' $\lambda = 0.955$, $F_{(1.89)} = 4.193$, $p < 0.044$, $\omega_p^2 = 0.02$; see Table 2). The main effect of groups was not significant. The two treatment groups taken together reduced their weight from $M = 217.52$ (SD = 36.85) at Time 1 to 213.84 (SD = 36.07), reflecting an average

Table 1. Means (M) and standard deviations (SD) for outcome variables by condition, with Time 1 values substituting for missing values at Time 2.

		CAD-only ($n = 30$)		CAD+G ($n = 31$)[b]		Control ($n = 30$)[b]	
		M	SD	M	SD	M	SD
Weight in pounds[a]	T1	215.22	35.74	219.75	38.35	217.28	35.43
	T2	211.58	34.27	216.02	38.16	216.12	35.50
BMI	T1	34.81	5.96	34.48	5.03	34.54	5.28
	T2	34.25	5.89	33.90	5.12	34.35	5.30
Total cholesterol	T1	192.00	33.66	188.45	27.55	190.07	23.45
	T2	185.90	29.49	179.57	23.76	184.86	22.02
Cholesterol ratio	T1	5.80	2.11	5.79	1.69	5.38	1.54
	T2	5.98	1.86	6.01	1.71	5.80	1.87
Triglycerides	T1	170.47	83.18	143.22	76.46	149.34	85.56
	T2	154.40	81.70	123.00	72.26	122.07	81.09

Notes: Means and standard deviations refer to the adjusted data set (including missing value substitution); T1 = Time 1 (intake); T2 = Time 2 (3-month follow-up).
[a]Weight not analysed in subsequent analyses because of substantial overlap with BMI ($r = 0.82$).
[b]Lipid panel results were not available for a single participant in the respective group.

Table 2. Two (treatments *vs.* control)-by-two (pre-intervention *vs.* 3-month follow-up) repeated measures (M)ANOVAs, simple effect ANOVAs and effect sizes for the data in Table 1.

	Main analyses				Simple effects ANOVAs for time			
	Time		Group * Time		Treatments		Control	
DV: BMI	F	ω_p^2	F	ω_p^2	F	ω_p^2	F	ω_p^2
	16.41***	0.087	4.19*	0.019	28.17***	0.182	1.50	0.008
DV: Lipid panels								
Multivariate effects	9.60***	0.138	0.32	0.000				
Total cholesterol	7.81**	0.041	0.25	0.000				
Cholesterol ratio	5.07	0.025	0.63	0.000				
Triglycerides	18.44***	0.098	0.03	0.000				

Note: None of the main effects of group were significant, therefore not displayed in Table 2.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

weight loss of 3.68 pounds and 0.57 BMI units during the first 3 months of the trial. The respective simple main effect was highly significant with a substantial effect size of $\omega_p^2 = 0.182$ (Wilks' $\lambda = 0.691$, $F_{(1.89)} = 28.17$, $p < 0.001$). Among control group members, weight loss was limited to an average of 1.16 pounds and 0.186 BMI units ($\omega_p^2 = 0.008$), which was not significant (Wilks' $\lambda = 0.945$, $F_{(1.89)} = 1.50$).

Next, a two (intervention *vs.* control)-by-two (T1–T2) repeated measures MANOVA was performed with the lipid panel data. Only the multivariate effect of time was significant (Wilks' $\lambda = 0.747$, $F_{(3.85)} = 9.60$, $p < 0.001$, $\omega_p^2 = 0.138$). Univariate effects for time showed a significant reduction across the entire sample in total cholesterol ($F_{(1.87)} = 7.81$, $p < 0.05$, $\omega_p^2 = 0.041$) and triglycerides ($F_{(1.87)} = 18.44$, $p < 0.001$, $\omega_p^2 = 0.098$), but no change for cholesterol ratio ($F_{(1.87)} = 5.07$, ns).

Table 3. 3-month and 6-month follow-up means (M) and standard deviations (SD) in the two intervention groups, with waitlist-control members integrated into CAD-only and CAD+G.

	CAD-only ($n=43$)				CAD+G ($n=44$)			
	3-month FU		6-month FU		3-month FU		6-month FU	
	M	SD	M	SD	M	SD	M	SD
Body weight								
Weight in pounds[a]	214.26	35.30	216.58	36.44	213.55	37.84	213.30	38.25
BMI	34.27	5.80	34.63	5.92	33.93	5.55	33.89	5.45
Lipid panel								
Total cholesterol	183.00	27.56	194.53	26.47	176.14	33.70	183.67	25.95
Cholesterol ratio	5.93	1.79	5.80	2.05	5.80	1.73	6.09	1.85
Triglycerides	129.98	81.94	144.60	86.73	123.43	73.22	119.82	93.30

Note: Means and standard deviations refer to the adjusted data set (including missing value substitution and outlier treatment).
[a]Weight not analysed in subsequent analyses because of substantial overlap with BMI ($r=0.82$).

Comparison of weight loss maintenance in the two intervention groups

According to Hypothesis 2, CAD augmented by a self-management group intervention should be more successful in preventing weight regain than CAD alone. This hypothesis was tested with a two (CAD-only *vs.* CAD+G)-by-two (3-month *vs.* 6-month follow-up) ANOVA using BMI as dependent variable and integrating control group members according to the treatment to which they were randomised at T2. Only the group-by-time interaction was significant at the significance level of $\alpha=0.10$ applied to the interactions (Wilks' $\lambda=0.961$, $F_{(1.85)}=3.45$, $p=0.067$, $\omega_p^2=0.014$). The main effects of time and groups were not significant. To further investigate the nature of the significant interaction, simple repeated measures ANOVAs were performed for the two groups separately. In the CAD-only condition, a significant weight regain of 2.32 pounds was observed ($\Delta_{BMI}=0.36$ units; $F_{(1.85)}=5.70$, $p<0.05$, $\omega_p^2=0.052$). In contrast, no weight change was observed in the CAD + G condition between the two follow-up assessment points ($\Delta_{BMI}=-0.04$ units; $F_{(1.85)}=0.05$, ns), indicating that the members of this group retained, on average, their initial weight loss of about 3.5 pounds (Table 3).

A corresponding MANOVA with lipid panel results revealed a significant multivariate effects of time (Wilks' $\gamma=0.877$, $F_{(3.83)}=3.87$, $p=0.012$, $\omega_p^2=0.047$) but no significant main effects of time and treatment condition (Table 4). Univariate tests for time showed a significant increase in total cholesterol ($F_{(1.85)}=11.67$, $p=0.01$, $\omega_p^2=0.058$). Although the increase in total cholesterol was stronger in the CAD-only condition relative to the CAD+G condition, the group-by-time interaction was not significant. No further significant effects were found.

Discussion

The results of this pilot study indicate that CAD interventions can assist overweight individuals in losing weight without the prescription of a specific diet or calorie limit. Both CAD-only and CAD augmented by self-management group training produced greater weight loss during the first 3 months of the trial compared to the waitlist control group.

Table 4. Two (CAD-only *vs*. CAD+G)-by-two (3-month to 6-month follow-up) repeated measures (M)ANOVAs, simple effect ANOVAs and effect sizes for the data in Table 3.

	Main analyses				Simple effects ANOVAs for time			
	Time		Group * Time		CAD-only		CAD+G	
DV: BMI	F	ω_p^2	F	ω_p^2	F	ω_p^2	F	ω_p^2
	2.37	0.008	3.45*	0.014	5.70*	0.052	0.051	0.000
DV: Lipid panels								
Multivariate effects	3.87*	0.047	1.14	0.000				
Total cholesterol	11.67**	0.058	0.51	0.000				
Cholesterol ratio	0.21	0.000	1.44	0.003				
Triglycerides	0.79	0.000	2.16	0.007				

Note: None of the main effects of group were significant, therefore not displayed in Table 4.
*$p < 0.05$; ** $p < 0.01$.

The initial success of the interventions can best be attributed to the introduction of the NutriGenie software as a self-monitoring device, in combination with personalised goal setting and feedback. During the first 3 months of the trial, the four-session self-management group intervention did not appear to provide any additional benefits beyond the effects that were achieved with a one-session CAD intervention plus software. In both intervention groups, an approximate weight loss of 3.7 pounds was observed. However, a tendency towards differential effects of the two intervention conditions became apparent at the 6-month follow-up. CAD-only was not successful in helping participants maintain their initial weight loss over time. On average, CAD-only members returned to their original weight. In contrast, CAD+G participants were able to fully retain their initial weight loss. Thus, the additional self-management training, although not necessarily more successful in accelerating weight loss in the initial phase of an intervention trial, may be more successful in preventing weight regains.

Both interventions were based on volition theory (Kuhl, 1985; Schwarzer, 1992, 2002) and used elements highlighted in the self-control literature (Kanfer et al., 1991, 2005). The interventions targeted the post-intentional, volitional phase of behaviour change, focusing on action control among individuals whose goals are set. Volitional interventions focus on strategies that enhance the intention-behaviour congruency and thus, the likelihood of goal achievement. Both interventions targeted self-monitoring as a basic tool in the process of self-induced change. However, long-term behaviour change requires more than a short-term application of self-monitoring as the arguably most crucial element of self-management. The hypothesis underlying the CAD+G intervention claimed that general self-control skills need to be improved to support long-term maintenance of a healthy and weight-friendly diet (Schroder & Schwarzer, 2005). Thus, the four-session group interventions targeted a variety of important supplemental self-management skills and strategies, with a strong focus on long-term maintenance. The study does not allow separating the specific components that were particularly useful in supporting long-term maintenance of weight loss. However, it is most likely that an improvement in general self-management skills and not an isolated strategy is responsible for greater long-term success.

Why did the interventions not lead to the desired weight loss of one pound per week? One reason for the modest weight loss may reside in the fact that an estimate of

'maintenance calories', and thus, the calorie limit required to achieve a weight loss of one pound per week were, in part, based on participant ratings of physical activity, which might reflect over-estimates of current activity levels or unrealistic estimates of future activity. Alternatively, participants may have failed to adhere or consciously decided to relax calorie restrictions on numerous personal or public holidays during the course of the study. Finally, the interventions may not have been intense enough to support the substantial weight loss targeted by the participants. Thus, future interventions may need to expand on the number of sessions, apply a more accurate measure of calorie expenditure in calculating individual calorie limits, and work more intensely on factors that limit successful weight control.

How do the results of this study compare to the effects of similar intervention trials reported in the literature? In contrast to previous computer-tailored dieting interventions (Kroeze, Werkman, & Brug, 2006), our study featured weight loss as the primary outcome of interest. To our knowledge, only few CAD interventions reported in the literature evaluated intervention effects on weight loss. Among recruits from a health maintenance organisation, Wylie-Rosett et al. (2001) reported an average weight loss of 4.7 pounds over the course of a year for a combined (dieting and exercise) computer-assisted lifestyle intervention and an average weight loss of 7.4 pounds for the same intervention augmented by staff counselling. Similarly, Hunter et al. (2008) reported about the results of a 24-week internet-based weight control intervention featuring weekly internet lessons, electronic food and exercise diaries, weekly counsellor feedback and two motivational interviewing sessions with the counsellor over the course of the intervention. While intervention completers experienced an average weight loss of 3 lbs, usual care control participants gained about 1.3 lbs over a 6-month period. These results appear to be stronger than the intervention effects achieved in the present study; however, both the results reported in Wylie-Rosett et al. (2001) and Hunter et al. (2008) refer to completers only. Using study completers only (i.e. participants who returned to at least one follow-up), the average weight loss in the present study was about 4.2 pounds in the two intervention groups, which compares well with the findings of these authors.

In sum, there is strong evidence that computer-assisted interventions can provide an efficient, easy to implement, and low-cost alternative to traditional lifestyle interventions that are considerably more cost-intensive and less feasible for broad dissemination. Although an average weight loss of only 3.7 pounds in the intent-to-treat analyses might appear small (translating into a 1.7% reduction in body weight), the long-term benefits of a brief nutrition education combined with self-monitoring and self-management skills training might be more impressive with greater follow-up intervals. More aggressive weight loss interventions achieve greater initial weight reductions (NIH, 1998); however, it is questionable whether these are retained over long periods of time, once participants return to less restrictive eating habits.

Several limitations of the present study may constrain the generalisation of the results. First, the relatively small sample size limits external validity and indicates the need for replication. Second, interventions focusing on self-monitoring and additional self-management skills might not be successful among persons lacking the self-motivation to lose weight. That is, patients transferred to a dietary program by their health care provider (rather than seeking out a weight-loss program on their own) may not benefit from self-management tools and training without a preceding motivation-building intervention. Third, the generalisation of our results is limited to a population matching the characteristics of our sample, which was dominated by white, middle-aged, well-educated, primarily female participants recruited in a metropolitan area of the mid-Western

United States. Fourth, the long-term self-monitoring of dietary intake requires constant computer access, which might limit the feasibility of this approach to individuals who are in the possession of a personal computer. Finally, the limited number of male participants in this study did not allow testing for gender differences and further limits the generalisability of the findings.

In conclusion, the results of the present study indicate that a computerised nutrition intervention may have potential in supporting self-guided weight loss attempts among overweight and obese people. However, the intervention may need to be refined and intensified in order to achieve greater effectiveness. Although additional self-management training appears to be a promising approach towards long-term success, no data are available beyond the 6 months following the introduction to the nutrition software. Further research would need to evaluate long-term effects of CAD-based interventions on weight loss as well as the need for additional self-management booster sessions beyond the initial intervention phase.

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