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RESEARCH PAPER

Effects of a brief computer-assisted diabetes self-management intervention on dietary, biological and quality-of-life outcomes

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Objective: There is a need for practical, efficient and broad-reaching diabetes self-management interventions that can produce changes in lifestyle behaviours such as healthy eating and weight loss. The objective of this study was to evaluate such a computer-assisted intervention.
Methods: Type 2 diabetes primary care patients ($n = 335$) from fee-for-service and health maintenance organization settings were randomized to social cognitive theory-based tailored self-management (TSM) or computer-aided enhanced usual care (UC). Intervention consisted of computer-assisted self-management assessment and feedback, tailored goal-setting, barrier identification, and problem-solving, followed by health counsellor interaction and follow-up calls. Outcomes were changes in dietary behaviours (fat and fruit/vegetable intake), haemoglobin A1c (HbA1c), lipids, weight, quality of life, and depression.
Results: TSM patients reduced dietary fat intake and weight significantly more than UC patients at the 2-month follow-up. Among patients having elevated levels of HbA1c, lipids or depression at baseline, there were consistent directional trends favouring intervention, but these differences did not reach significance. The intervention proved feasible and was implemented successfully by a variety of staff.
Conclusions: This relatively low-intensity intervention appealed to a large, generally representative sample of patients, was well implemented, and produced improvement in targeted behaviours. Implications of this practical clinical trial for dissemination are discussed.

Keywords: Diabetes, Self-management, Computer intervention, Dietary change, Randomized controlled trial

INTRODUCTION

There is an increasing need for diabetes self-management education (DSME). Central to effective DSME are strategies to help patients engage in healthy eating and regular physical activity.[1–3] However, the majority of diabetes patients have not received DSME[4] and do not attend typical group-based education programmes.[5] Primary care offices are overwhelmed with a variety of competing demands, and generally do not have the resources or time to provide DSME.[6–9] To address these issues, our research group has been investigating computer-assisted DSME that is conducted in conjunction with and begins with a strong referral system from primary care, but takes place outside the primary care settings.[10,11]

The emerging literature on the application of interactive technology to health behaviour change is encouraging,[3,5,12–14] but challenges remain in applying interactive technologies

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to DSME.[15] It appears that the most effective self-management interventions: (1) incorporate the patient as an active participant in goal-setting and self-management; (2) are explicitly based on behavioural theory; and (3) use information systems to help plan and prompt care and to proactively reach out to patients.[16] Such interventions are needed to change the culture of care from a physician-centred acute care model to a chronic care model.[2,17,18]

From our previous research and recent literature, it appears that primary care practices are much more likely to support DSME and participate in programmes if the education and counselling does not have to take place in the primary care setting.[19–21] The chronic care model and supporting literature have shown that self-management should be linked back to, and integrated with, primary care rather than being an unrelated activity.[22,23] The tailored self-management (TSM) programme was designed to be broadly applicable, feasible to conduct in many settings and by a variety of staff (including those with little diabetes experience), and address questions related to dissemination. We used a randomized, practical clinical trial design[24,25] to evaluate the effects of our interactive technology-assisted TSM on a variety of outcomes, in two types of healthcare setting, when delivered by a variety of different counsellors, and compared it to a computer-assisted health risk appraisal and feedback programme.

The primary purposes of this article are to report on (1) the short-term (2-month) dietary, biological and quality-of-life outcomes from TSM, (2) the implementation and feasibility of the programme, and (3) implications for broader dissemination.[19,26]

METHODS

Design

A patient-level randomized practical clinical trial design[24,25] was employed. Since the actual intervention took place and was conducted by automated procedures and staff external to primary care, it was possible to randomize patients within physician. The design incorporated the key elements of practical clinical trials by: (1) including heterogeneous patients, representative of those seen in primary care and employing few exclusion criteria; (2) studying multiple settings, including both mixed-payer, fee-for-service and managed-care offices; (3) comparing the TSM intervention to a condition similar to that employed in many settings (and to control for number of additional meetings and exposure to computer assisted assessment and feedback) incorporating a health risk appraisal, feedback, and brief, generic health habit change counselling; and (4) evaluating outcomes across a variety of measures important to practising clinicians and decision-makers, including quality of life. Sample size calculation conducted prior to the study indicated that a sample size of 150 patients per condition (300 total) would provide a power of 0.90 to detect an effect size of 0.3 standard deviation.

Recruitment Procedures and Participants

Adults diagnosed with type 2 diabetes residing in the Denver, Colorado metropolitan area were recruited from lists provided by 42 participating physicians (20% from mixed-payer settings, and the remainder employed by Kaiser Permanente Colorado). Lists were developed of all type 2 diabetes patients aged 25 years and older cared for by participating physicians. Physicians had the option of excluding patients for whom they felt the intervention would not be appropriate, but it was exceptionally rare to have even a single patient excluded. On average, there were eight patients who participated per physician (range = 1–12), and this number did not differ across experimental conditions. All patients were posted letters describing the study, followed by telephone contact to provide study details and ascertain eligibility. Eligible participants were at least 25 years

old, diagnosed with type 2 diabetes for at least 6 months, and able to read and write in English. Eligible and interested patients were scheduled for their baseline visit and, after termination of the call, were randomized to intervention or control conditions (Fig. 1). All procedures were approved by the Kaiser Permanente Colorado Human Subjects Review Board.

As shown in Table 1, participants were typical of type 2 patients with diabetes seen in primary care. As reported in detail elsewhere,[27,28] 41% of eligible patients participated. The only characteristics available for non-participants were age and gender, and there were no differences between participants and non-participants on these measures. They were older (average age 62 years), overweight (body mass index over 31 kg/m^2), and had on average three other co-morbid chronic illnesses. The sample was evenly split between men and women, and 18% were of Hispanic ethnicity. Although participants were relatively highly educated, with 35% having a college degree, there was a range of family income levels. Sixty-four per cent reported annual family incomes $<$\$50,000 and 28% had incomes $<$\$30,000.

Tailored Self-management Intervention

The primary intervention was conducted at a location external to the participant's primary care setting. This was typically a central clinic or medical office not too distant from the participant's home. The CD-ROM program focused on healthy eating and physical activity, and addressed key aspects of our self-management model (Fig. 2). The TSM intervention incorporated key

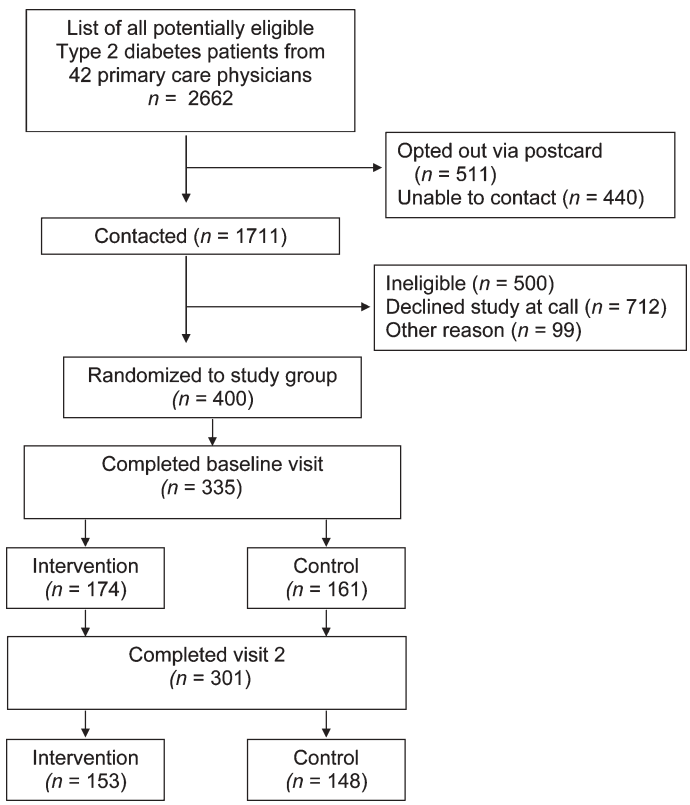

FIG. 1. CONSORT diagram of study participation.

TABLE 1. *Participant characteristics at baseline (n = 335)*

	All, $n = 335$	TSM, $n = 174$	UC, $n = 161$	p
Age (years), mean (SD)	61.5 (11.3)	62.0 (11.7)	61.0 (11.0)	0.43
Co-morbidities (range = 0–10), mean (SD)	3.0 (2.0)	2.9 (1.9)	3.1 (2.1)	0.61
Body mass index, kg/m^2, mean (SD)	31.6 (7.1)	31.3 (7.0)	31.9 (7.2)	0.42
% Taking insulin	22.0	24.2	19.2	0.28
% Female	50.2	50.3	50.0	0.96
% Married	65.7	67.6	63.5	0.43
Education level completed				0.30
% High school	29.3	30.8	27.6	
% Technical school	35.4	33.7	37.2	
% College	20.1	17.4	23.1	
% Graduate degree	15.2	18.0	12.2	
% Hispanic	17.9	17.5	18.3	0.86
% White	76.7	74.1	79.6	0.24
Income				0.49
% Less than $10,000	5.1	4.9	5.4	
% $10,000 to $29,999	22.4	25.0	19.5	
% $30,000 to $49,999	31.6	28.0	35.6	
% $50,000 to $69,999	19.5	20.1	18.8	
% $70,000 to $89,999	10.9	12.8	8.7	
% $90,000 or more	10.5	9.1	12.1	
% Smokers	9.9	8.1	11.9	0.25

Note: The TSM intervention group received tailored self-management intervention. The UC (usual care) comparison group received computer-assisted generic health risk appraisal.

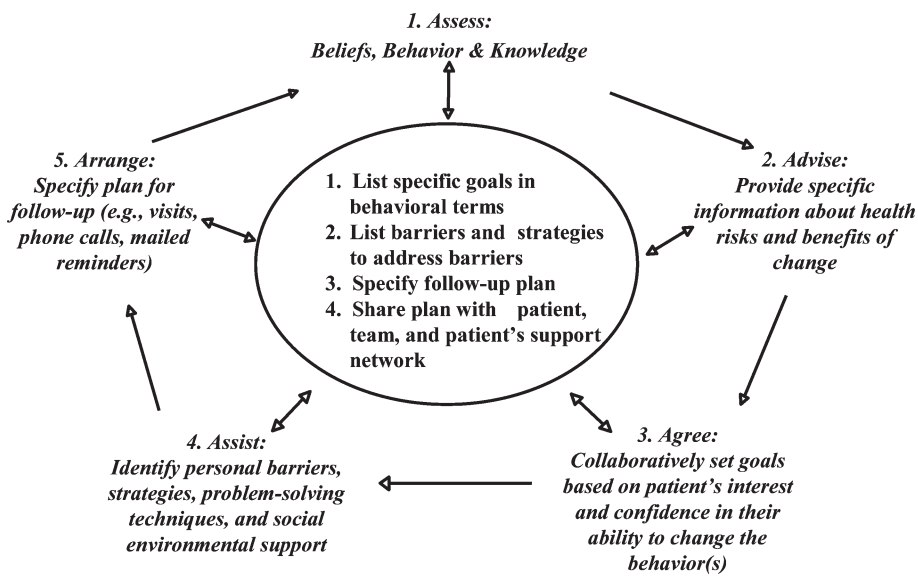

FIG. 2. Self-management model.

components of the chronic care model self-management framework,[22,23,29] including assessment of current health behaviour, feedback, identification of benefits and barriers to change, and tailored goal-setting and action-planning, all of which were automated within the CD-ROM program. In addition, tailored follow-up letters reinforcing the patient's selected goals (with space for the coach to write in patient laboratory

results) were automatically generated by the computer program. Health educators (i.e. 'health coaches') trained in motivational interviewing techniques,[30] with varying educational backgrounds but with no formal training and little or no experience in diabetes, answered any questions and helped to ensure that the final plan was appropriate for the individual.

Both the computer program and the health-coaching session emphasized motivating factors and barriers to healthy eating and physical activity, a method used in nutrition research to help initiate and sustain behaviour change.[31] The benefits identified the participant's motivation for change, while the barriers created a basis for problem-solving during the action-planning portion of the program. The computer presented a comprehensive list of benefits of and barriers to healthy eating and being physically active, and patients were allowed to write in their own benefits and barriers if they did not find one that suited them. The diet-related items are summarized in Tables 2 and 3. By allowing a 'write-in' option, it was possible to compile a highly personalized and inclusive list from which to tailor counselling. The program next produced lists of suggested strategies tailored to the individual's identified barriers. A write-in strategy option was also provided to maximize personalization of the action plan.

Once goals, benefits, barriers and strategies were selected, participants were asked to rate their self-efficacy or confidence in achieving the goals and carrying out the strategies delineated in their action plans. To do this, the computer program asked

TABLE 2. *Most frequently selected benefits of healthy eating*

Makes me feel healthier (49%)
Decreases my risk of disease (47%)
Increases my energy level (38%)
Helps me maintain or lose weight (43%)
Helps my digestion/keeps me regular (8%)
Improves my appearance (6%)
Allows me to snack on healthy food without guilt (6%)
Makes me a role model for my family (3%)

TABLE 3. *Most frequently selected barriers to and computer-generated strategies for healthy eating*

I have little or no self-discipline (especially when under stress) (52%)	Prepare healthy foods ahead of time
I tend to overeat (46%)	Plan ahead for 'high-risk' eating situations
	After eating a small to medium serving, wait to see if you are still hungry before having another helping
I eat out so it's hard to control ingredients and/or portion sizes (30%)	Experiment with eating more slowly and having smaller portions
	Look for restaurants that will prepare foods in a healthier way, or offer healthier choices
I don't have time to cook, so we buy a lot of fast food (19%)	When eating out, eat half as much as you normally would
	Choose a lower-fat meal when eating at a fast food restaurant
Healthy foods are too expensive (10%)	When travelling or on the run, carry healthy foods with you
	If healthy eating is a priority for you, find ways to cut expenses in other areas
I don't know how to prepare healthy foods like fruits and vegetables (9%)	Many healthy food choices are also inexpensive; click (here) for tips
	Prepare foods you already know how to cook, but in a healthier way
My family wants high-fat food/hates fruits and vegetables (8%)	Prepare and serve food in individual portion-sizes
	Wean your family from their fatty foods one step at a time
	Separate out your portion before extra butter or other saturated fats are added to family meals
I just don't like health foods (8%)	Look for ways to add fruits and vegetables to dishes you like
	Don't deprive yourself of your favourite foods — just substitute lower-fat ingredients

Note. Although no participant chose the write-in option to list a different healthy diet benefit from those presented, 17% wrote in an additional barrier to eating healthily.

participants to rate on a scale of 1–10 how confident they were that they could implement their action plans over the next 2 months.[32,33]

If a participant rated self-efficacy at less than 7 on the ten-point scale, the computer program encouraged revision of the plan. The ability to revise the plan was intended to foster a sense of control, and assure the participant that a revised action plan could be created with a less aggressive, more achievable goal that the participant might feel more confident about achieving. Only 30% of participants rated their dietary plan less than 7 initially. Of these participants, most opted to revise strategies (48%) rather than dietary barriers (20%) or goals (32%). If, after revision of the plan, self-efficacy remained low, individuals were encouraged to discuss their concerns about achieving their goals with their coach. The coach could then help them to individualize their goals or plans further, based on lifestyle and current situation, with the hope of increasing self-efficacy and reducing resistance to behaviour change. Coaches reviewed proper food portion size, nutritional balance, and fat, fruit and vegetable intake.

The plan was then translated by the computer program into a printout that was used as a tool[34] for dialogue between the patient and their health coach. Participants were also encouraged to discuss their plan with their physicians and healthcare teams. Health coaches were trained to conduct the sessions via role play, hands-on practice, and exposure to motivational interviewing techniques,[35,36] using training video-tapes created by Miller and Rollnick.[37]

Results of the patient's laboratory tests were reviewed, if available at the time of the appointment. Otherwise, laboratory test results were mailed to patients in a computer-generated letter that also restated their goals. At approximately 1 week and 1 month after the first visit, participants received a follow-up call, averaging 10–15 min, from their health coach to review their goals, barriers, and strategies, and reinforce or revise their plan as appropriate. A tailored health newsletter was also mailed approximately 6 weeks after the first visit.

In addition to the participant's printout, the computer produced a one-page summary that was sent to the patient's physician. The physician printout permitted quick scanning by the physician for integration during a routine visit. It was either faxed to the physician's office or scanned into the patient's electronic medical record, as preferred by the physician. Physicians of both TSM and computer-aided enhanced usual care (UC) patients were also sent the results of the lipid panel and haemoglobin A1c (HbA1c) levels from samples obtained at each study visit.

Measures

Dietary change was assessed with the Block fat screener,[38] which estimates dietary fat intake based on 15 high-fat food items. Fruit and vegetable intake was assessed with the All Day NCI Fruit and Vegetable Screener.[39] Diabetes-specific quality of life was assessed with the revised Diabetes Distress Scale, a recently developed version of the original Problem Areas in Diabetes Scale.[40] The earlier version has been demonstrated to be reliable and sensitive to change.[41,42] In the present study, the Diabetes Distress Scale had an internal consistency of alpha = 0.93. The Patient Health Questionnaire (PHQ) is a self-administered instrument that has been validated as a diagnostic and depression severity measure.[42] The PHQ-9 scores each of the nine DSM-IV depression criteria on a 0 (not at all) to 3 (nearly every day) scale. A score of 10 has been documented to have a sensitivity of 88% and a specificity of 88% for major depression.[42] In the present study, the scale exhibited good internal consistency (alpha = 0.86).

Biological effectiveness was evaluated by changes in HbA1c and lipid ratio [ratio of total cholesterol to high-density lipoprotein (HDL) cholesterol]. A National Glycohemoglobin Standardization Program (NGSP) certified Bio-Rad Variant 2 analyzer was

used for the HbA1c tests, correlated with an index of glycaemic control established during the Diabetes Control and Complications Trial (DCCT). The reference range used was 4.1–6.5%. Fasting lipid profiles were determined using Roche methodologies. Enzymatic methods were used to determine total cholesterol and triglyceride levels. The HDL level was determined using a direct homogeneous enzymatic process. The low-density lipoprotein level was calculated for fasting profiles if the triglyceride level was less than 400 mg/dl. If the triglyceride level was greater than 399 mg/dl, a direct homogeneous enzymatic method was used.

RESULTS

Preliminary Analyses

There were no baseline differences between conditions on any dependent variables (Table 4), or on demographic or medical history factors potentially related to treatment outcome (Table 1). As shown in Fig. 1, attrition was modest (10%) by the 2-month assessment, and not different across conditions. Because of this low attrition rate, we used complete-case analyses in the present investigation, but intention-to-treat analyses with baseline values substituted for missing cases produced identical conclusions.

TABLE 4. *Baseline and 2-month mean (standard deviation), and significance of between-condition ANCOVA on outcome variables*

	All	TSM	UC	Tx effect, *p*
Fruit and Vegetable Screener score				0.27
Baseline	5.3 (3.4)	5.5 (3.8)	5.1 (3.0)	
Visit 2	5.4 (4.2)	5.7 (4.8)	5.0 (3.4)	
Estimated daily fat intake				0.006
Baseline	29.9 (19.5)	27.6 (17.9)	32.4 (20.9)	
Visit 2	25.4 (16.7)	22.4 (15.2)	28.5 (17.8)	
Haemoglobin A1c, %				0.46
Baseline	7.4 (1.6)	7.4 (1.6)	7.5 (1.6)	
Visit 2	7.4 (1.6)	7.3 (1.5)	7.5 (1.8)	
Total cholesterol/HDL cholesterol				0.33
Baseline	3.9 (1.1)	3.9 (1.2)	3.9 (1.0)	
Visit 2	3.8 (1.0)	3.8 (1.0)	3.8 (1.1)	
Total cholesterol, mg/dl				0.27
Baseline	185.1 (43.8)	185.1 (45.3)	185.1 (42.2)	
Visit 2	183.6 (37.3)	183.1 (38.8)	184.1 (35.8)	
HDL cholesterol, mg/dl				0.083
Baseline	49.6 (15.2)	49.2 (16.2)	50.0 (14.1)	
Visit 2	50.6 (14.9)	50.4 (15.2)	50.9 (14.6)	
PHQ-9 total score				0.53
Baseline	5.6 (5.0)	5.7 (4.9)	5.4 (5.1)	
Visit 2	5.5 (5.1)	5.5 (5.0)	5.5 (5.3)	
Diabetes Distress Scale				0.29
Baseline	40.8 (18.1)	40.1 (17.5)	41.5 (18.9)	
Visit 2	34.9 (15.6)	33.6 (14.2)	36.2 (17.0)	
Weight, Kg				0.007
Baseline	94.1 (20.2)	94.3 (24.6)	94.0 (24.5)	
Visit 2	93.8 (24.0)	93.6 (23.6)	94.0 (24.5)	

TSM, tailored self-management; UC, usual care; Tx, treatment.
Note: Sample sizes are as follows. Baseline: $n=333$ (TSM, $n=160$; UC, $n=173$). Visit 2: $n=299$ (TSM, $n=147$; UC, $n=152$).

Primary Analyses

Primary analyses compared the effect of treatment conditions on dietary behaviour change. These ANCOVAs revealed a significant and clinically meaningful reduction in dietary fat intake in TSM participants compared to enhanced UC participants (Table 4). However, there were no overall between-condition differences in fruit and vegetable consumption. This may have been because fewer TSM participants elected to focus on fruit and vegetable intake (36%) than on saturated fat intake. Among TSM participants who focused on increasing fruit and vegetable intake, the average increase was 2.3 servings (from 3.9 at baseline to 6.2 at 2 months), compared to a 0.8 serving decrease for TSM participants focused on reducing fat intake and virtually no change for enhanced UC participants (from 5.1 at baseline to 5.0 at 2 months) [$F(2,286) = 4.97$, $p = 0.008$)].

Secondary Analyses

As shown in Table 4, ANCOVAs were also conducted on biological outcomes, mood, and quality-of-life measures. TSM produced significantly greater weight loss than the enhanced UC condition ($p = 0.0007$), although the magnitude of weight loss differences (0.68 kg) over the 2-month period was modest. No other biological or quality-of-life comparisons revealed significant between-condition differences. This may have been partially due to the good baseline scores on a number of these measures. For example, 53% of the sample had baseline HbA1c values less than 8.0, and 40% had total cholesterol/HDL cholesterol ratios less than 4.0. *Post hoc* analyses among the subset of participants not meeting clinical recommendations at baseline (e.g. HbA1c $\geq 8.0\%$, total cholesterol/HDL cholesterol ≥ 4.0, PHQ-9 score ≥ 10) revealed a consistent trend for greater improvement among TSM than among control participants. These differences did not reach significance (Table 5), possibly because of the smaller sample sizes.

Implementation and Robustness

The TSM program was consistently implemented. All participants received the computer-assisted and staff-counselling interactions, and 96% received a follow-up phone call. Staff members with different backgrounds and education levels were able to successfully implement the program. TSM also appeared to be robust across a variety of patient characteristics. Moderator analyses were conducted to evaluate potential interaction effects on all outcomes (fruit and vegetable intake, fat intake, HbA1c, total cholesterol/HDL cholesterol, total

TABLE 5. *Intervention effects on outcomes for participants not meeting clinical recommendations at baseline*

	All	TSM	UC	Tx effect, p
Total cholesterol/HDL cholesterol*				0.07
Baseline	4.8 (0.8)	4.8 (0.9)	4.8 (0.6)	
Visit 2	4.5 (0.9)	4.4 (0.9)	4.7 (0.9)	
Haemoglobin A1c†, %				0.19
Baseline	9.3 (1.6)	9.2 (1.6)	9.4 (1.5)	
Visit 2	9.1 (1.8)	8.9 (2.0)	9.4 (1.6)	
PHQ-9 total score‡				0.23
Baseline	13.5 (3.4)	13.6 (3.1)	13.4 (3.8)	
Visit 2	11.4 (5.8)	10.6 (5.5)	13.0 (6.0)	

TSM, tailored self-management; UC, usual care; Tx, treatment.
*$n = 114$ for all cases, $n = 61$ for TSM, $n = 53$ for UC.
†$n = 71$ for all cases, $n = 32$ for TSM, $n = 39$ for UC.
‡$n = 57$ for all cases, $n = 30$ for TSM, $n = 27$ for UC.

cholesterol, and PHQ) between treatment conditions and a number of variables (i.e. age, number of co-morbid conditions, type of medication, gender, marital status, education, ethnicity, income, smoking status, and health maintenance organisation (HMO) *v.* non-HMO physician setting). All were non-significant at $p < 0.01$ (correcting for the large number of comparisons), with the exception of the interaction between treatment group and physician setting on the total cholesterol outcome ($p = 0.009$), with non-HMO patients improving more in the treatment condition and worsening more in the control condition compared to HMO patients. Given the general lack of interaction effects in these 60 comparisons, the program appears to be equally effective across the sub-populations.

DISCUSSION

Summary of Findings

The primary goal of this study was to evaluate the effects of the TSM program on dietary change, with secondary aims being to assess improvements in biological measures and quality of life/depression. TSM produced significantly greater improvements in dietary fat intake, but not in fruit and vegetable intake. This finding is consistent with computer-based multi-media interventions with other patient populations.[3] The reduced level of effect on fruit and vegetable intake may have been because participants were given the choice of focusing on either fat consumption or fruit and vegetable consumption, to avoid overwhelming them with too many goals. Only 36% of participants selected a goal of increasing fruit and vegetable intake, and the smaller sample size reduced the power to detect effects on this outcome.

The TSM program also produced significantly greater weight loss than enhanced UC, although the magnitude of this effect was modest and not clinically significant. The effects of TSM on other outcomes were less clear. The most conservative and 'intention-to-treat' conclusion is that the program did not produce significantly greater improvements in remaining measures than did the enhanced UC condition, which itself may have produced some improvement. *Post hoc* sub-analyses, however, suggest that TSM may have had some effects among those with elevated levels at baseline of HbA1c, lipids, and depression, although these effects did not reach statistical significance with reduced sample sizes. It may also be that it will take longer than 2 months for the observed behaviour changes to translate into less proximal biological or quality-of-life improvements. It may be that such DSME interventions will need to be integrated with other care components to produce larger effects, especially on biological outcomes.

We employed a practical clinical trial design, which should have enhanced representativeness and external validity,[24,25] but may have reduced our ability to detect between-condition effects. By minimizing exclusion criteria, we probably included more of: (1) patients with multiple co-morbid conditions, depression, and other barriers; and (2) those who may have been less motivated. The program was offered without charge and involved few visits in comparison to traditional efficacy studies. Although our results should be more broadly generalizable, the decision to include multiple healthcare systems, providers, and intervention staff, as well as allowing patients to select different goal areas, probably introduced variability that reduced our ability to identify intervention effects.

Implications for Practice

From the results of this study, we draw several conclusionss concerning future interactive technology programs and DSME dissemination efforts. First, this type of theory-based program offering participant choice appears to be feasible, and seems to appeal to both physicians and patients. We attribute its success to the engaging

multi-media design, the patient-centred and choice components overlaid on effective behaviour change principles, and the connection to the patient's primary care. It is not clear whether the program can be entirely self-administered — the effects observed are due to a combination of the CD-ROM program and staff counselling. Weight loss might be enhanced by replacing the fruit-and-vegetable part of the TSM with a calory-reduction component. Offering the TSM program via the Internet might increase program reach and remove some participation barriers, but might produce less follow-through on goals.[5,43] Offering the program within the clinical setting, using nurses, dietitians or health educators as coaches, might also increase reach while providing an opportunity to better integrate the program into overall care.

Study Limitations

Study limitations include the restricted power to detect intervention effects, due to the issues discussed above, and the lack of a large number of minority participants. Although our sample was generally representative of the demographics of local and state diabetes patients, we did not offer the program in languages other than English, and it is unclear whether patients with low health literacy would participate or how they might benefit. Another drawback is the short assessment period, since it is common for initial intervention effects on dietary change and weight to dissipate over time. Strengths include the randomized practical clinical trial design, the inclusion of multiple outcomes, the basis in theory and use of a self-management model[29,44] to design the patient-centred TSM intervention, the reasonably large sample size, and the process evaluation to identify most frequently used components of the program.

Implications for Research

The TSM program appears to be feasible and is an example of how DSME might be packaged for broad-scale implementation. However, future research is needed to: evaluate this and similar computer-assisted DSME programs with low-health-literacy and non-English-speaking patients;[45] determine whether such programs are effective for other illnesses (since those with multiple conditions appeared to benefit, and the behaviour changes targeted are broadly applicable); and investigate the unique advantages and limitations of technology-based *v.* in-person combination programs. Above all, more practical clinical trials are needed for diabetes and other chronic illness conditions. A follow-up evaluation is being conducted on the longer-term effects of TSM, both with and without a specific maintenance/relapse prevention component.

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