

ORIGINAL RESEARCH

Assessment of readiness to prevent type 2 diabetes in a population of rural women with a history of gestational diabetes

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A B S T R A C T

Introduction: Women with a history of gestational diabetes mellitus (GDM) are at high risk of developing type 2 diabetes mellitus. Given the rapidly increasing prevalence of diabetes globally, there is an urgent need to develop preventative strategies and to identify high risk populations who would most benefit from diabetes prevention. Objective: To investigate readiness to prevent diabetes in a cohort of rural women with a recent history of GDM. Setting: Women with a recent history of GDM in regional and rural Victoria, Australia.

Methods: All women who had attended a regional diabetes centre in the past 14 months (June 2004 to July 2005) for treatment of GDM, were surveyed by mail. Variables measured included readiness to engage in physical activity and weight management as measured by the transtheoretical model of behaviour change, and perception of diabetes risk.

Results: Of the 53 women who completed the survey (mean age 32.5 years), 58% were classified as in pre-action for activity and 75% in pre-action for weight loss. Highest prevalence of pre-action for both activity and weight loss was among women with more than two children, high BMI, and those not engaged in paid work. Eighty-five percent of women in pre-action for activity were also in pre-action for weight loss. Neither physical activity nor weight loss behaviour was influenced by baby age. Nearly all



respondents agreed that regular exercise, healthy diet and healthy weight, were very important to prevent diabetes, and the majority of respondents were optimistic about preventing type 2 diabetes mellitus. However, just under half (43%) of the total cohort were not engaged in any diabetes risk reduction behaviour.

Conclusion: The prevalence of physical activity and weight loss behaviour was found to be low in a rural population of women with a history of GDM, despite a high awareness of diabetes prevention strategies. Future planning for diabetes prevention will need to target this knowledge-behaviour gap. In addition to child care services and partner support, programs designed to target ambivalence to behaviour change, including structured stage-matched interventions, may have success in this vulnerable and high risk group.

Key words: diabetes prevention, gestational diabetes, rural women, physical activity, stage of change, weight loss.

Introduction

Gestational diabetes mellitus (GDM), defined as glucose intolerance with onset or first recognition during pregnancy¹, occurs in 3.6% of pregnant women in Victoria Australia², increasing to 15% among some ethnic groups³. Women with a history of GDM are at high risk of developing type 2 diabetes mellitus (T2DM), with up to 70% developing T2DM, depending on ethnicity⁴. Given the rapidly increasing prevalence of diabetes globally, there is an urgent need to develop preventative strategies and to identify high risk populations who would most benefit from diabetes prevention^{5,6}. Individuals with impaired glucose tolerance are one such high risk population, and the results of several large randomised controlled trials indicate that T2DM is a potentially preventable condition⁷⁻⁹. Women with a history of GDM are another high risk population who would benefit from lifestyle interventions such as healthy weight, regular exercise and healthy eating. While approximately 15% of the population of women enrolled in the Diabetes Prevention Program had a history of GDM, there are limited studies targeting interventions to reduce diabetes risk in women with a history of GDM, and none involving rural women¹⁰.

Mothers with young children have difficulties engaging in healthy lifestyle programs because of lack of time, multiple commitments, lack of energy and resuming work¹¹⁻¹⁵. Successful healthy lifestyle programs must address these barriers and consider participants' readiness to make lifestyle

changes. The stages of change or transtheoretical model¹⁶ describes five stages in a person's readiness to change health behaviour. The first two stages represent individuals who are not ready to change (*pre-contemplation*) or who are ambivalent about change (*contemplation*). The third stage (*preparation*) represents individuals who have decided to make a change and intend to do so within the next month. The last two stages represent active behaviour change, with recent (*action*) or sustained, defined as more than 6 months, behaviour change (*maintenance*). Individuals can move in either direction between stages, usually in spiral rather than linear fashion, where relapse of behaviour is the rule rather than the exception¹⁷.

This pilot study aimed to examine the readiness of a cohort of rural women with a history of GDM to engage in diabetes risk reduction behaviour with respect to physical activity and achieving a healthy weight.

Background

The diabetes centre of a large regional hospital in northern Victoria, Australia is the major referral site for specialist care of women with GDM. Based on the 1998 Australasian Diabetes in Pregnancy Society (ADIPS) guidelines, all pregnant women are screened for GDM at 28 weeks gestation with a 50 g glucose challenge test. A 75 g oral glucose tolerance test (OGTT) is used to confirm the



diagnosis¹⁸. After the birth of their baby, women who have had GDM are routinely supplied with a pathology request for a repeat OGTT at 6 weeks postpartum, and are given lifestyle advice regarding the risk of developing T2DM. No routine follow up is offered to these women. The current system offers limited opportunities for effective diabetes prevention.

Methods

This pilot study examined a population of women who had attended the diabetes centre over a 14 month period (July 2004 to July 2005) for management of GDM. All women in this population were eligible, and women who were unable to complete the questionnaire but who wished to participate were given assistance to do so, for example by engaging an interpreter when a language barrier existed. Women were recruited by mail using contact details obtained from medical records. A survey package containing the questionnaire, plain language statement, consent and withdrawal of consent, was mailed to all women. A reminder letter was mailed 2 weeks after the initial survey, and a further survey package was mailed to those women who had not responded after 3 weeks. All participating women gave written informed consent to participate in the study. Approval was obtained from the Goulburn Valley Health Ethics Review Committee and the University of Melbourne Human Research Ethics Committee.

Stage of change was measured using a validated instrument (Appendix I) adapted from Marcus et al¹⁹, in which participants reported stage of change for physical activity and current weight loss behaviour. Perception of diabetes risk was assessed using a six-point Likert scale, with responses ranging from strongly agree to strongly disagree (Table 1). Descriptive information was collected about participants' ages, number of children, age of youngest child, postcode, working status, family income category and language spoken at home. Self-reported weight and height was used to calculate body mass index (BMI) in kg/m².

Physical activity was defined as walking, playing sport, cycling or dancing, for 20-30 min, three to five times weekly, which is recommended as minimum physical activity required for health benefits²⁰.

Statistical analysis

Due to small numbers in the study respondents were divided into *pre-action* (includes the women in pre-contemplation, contemplation and preparation stages) and *action* (includes the women in action and maintenance stages) groups for comparative analyses. To assess the relationship between stage of change for weight loss and other variables, women who reported their weight as being at a healthy level were excluded from analysis. Responses for perception of diabetes risk questions were categorised as disagree (1 & 2), neither agree nor disagree (3 & 4), and agree (5 & 6). Each completed questionnaire was coded, entered into a database and analysed using the Statistical Package for Social Sciences (SPSS Inc; Chicago, IL, USA). Statistical tests (χ squared, Fisher exact probability test, frequencies and cross tabulations) were conducted to test for differences in responses between the action and pre-action groups.

Results

There were 53 women who completed the survey (mean age 32.5 (± 5.08), mean \pm SD years); response rate 75%. Two-thirds of the women (68%) had two or more children, and half (49%) had a child less than 6 months old. A quarter (26%) had resumed paid work (part or full time). Fifteen percent reported Arabic as the primary language. Three women did not report their weight and three women did not report working status. Based on self-reported height and weight, 24% of women were overweight (BMI 25-29 kg/m²) and 42% were obese (BMI ≥ 30 kg/m²).



Table 1: Perception of risk of developing diabetes

Statement (N = 53)	Disagree n (%)	Neither agree nor disagree n (%)	Agree n (%)
Eating a healthy diet is important to my health	0	3 (6%)	50 (94%)
Maintaining a healthy weight is important to my health	0	5 (9%)	48 (91%)
Regular exercise is important to my health	0	7 (13%)	46 (87%)
It is very important for me to prevent diabetes	1 (2%)	7 (13%)	45 (85%)
Regularly being reminded to have a blood glucose test by the diabetes centre or my doctor would help me prevent diabetes.	7 (13%)	17 (32%)	29 (55%)
I am very confident I can prevent diabetes	4 (8%)	22 (41%)	27 (51%)
I do not feel motivated to think about my future health	35 (66%)	5 (10%)	13 (24%)
I feel I will get diabetes no matter what I do	32 (60%)	18 (34%)	3 (6%)

Table 2 shows that 58% of respondents were classified as pre-action for physical activity. Of these, 3% were at pre-contemplation stage, 45% at contemplation and 52% at the preparatory stage. In those respondents meeting activity guidelines, half were at action stage and half at maintenance stage. Women in pre-action for activity were slightly younger (mean age 31.5 ± 3.9) than women in action (mean age 34.1 ± 6.0). Prevalence of pre-action for activity was highest in women with a BMI above 25kg/m^2 , women in pre-action for weight loss and women not engaged in paid work. For the women in pre-action for activity, 85% were also in pre-action for weight loss. Physical activity did not appear to be influenced by baby age. Of the women with more than two children, two-thirds (61%) were in pre-action for activity and the majority (80%) were in pre-action for weight loss.

Seventeen percent of women felt their weight was at a healthy level. Of those women who felt they needed to lose weight 41% were at contemplation, 34% were at preparation for weight loss, 15% were at action and 10% were at maintenance for weight loss. The age of women in pre-action for weight loss (mean age 31.9 ± 4.5) was similar to women in action (mean age 31.7 ± 2.8). Table 3 summarises women who felt they needed to lose weight and shows that 75% of this group were in pre-action for weight loss. Prevalence of pre-action for weight loss was highest among

women with more than two children, not engaged in paid work; in pre-action for activity and women with a BMI above 25kg/m^2 . Prevalence of pre-action for weight loss was not influenced by baby age. Despite these trends, there were no statistically significant differences between women in pre-action and action for physical activity or weight loss.

Women engaging in optimal diabetes risk reduction would either be a healthy weight, or be actively losing weight while also being physically active. Of the total sample, 15 women (30%) were active and managing their weight; either having a healthy BMI or currently losing weight. These women were using all available opportunities for diabetes risk reduction. Nearly half (43%) were at pre-action for both activity and weight loss and so not engaging in any diabetes risk reduction behaviour.

Responses relating to risk of developing diabetes are summarised (Table 1). The majority of women agreed healthy lifestyle choices, eating a healthy diet, maintaining a healthy weight and doing regular exercise, were important for good health. Similarly, importance for preventing diabetes was rated highly. Two-thirds of respondents disagreed with the statements 'I do not feel motivated to think about my future health' and 'I feel I will get diabetes no matter what I do'.



Table 2: Prevalence of readiness for physical activity

Variable	Women's activity (stage)		Fisher's exact test (2 sided) <i>p</i> *
	Inactive (pre-action) <i>n</i> (%)	Active (action) <i>n</i> (%)	
All women (<i>n</i> = 53)	31 (58%)	22 (42%)	–
Working status (<i>n</i> = 50) [§]			
Working	6 (19%)	8 (42%)	.110
Not working	25 (81%)	11 (58%)	
Number of children (<i>n</i> = 53)			
1 child	9 (29%)	8 (36%)	.766
≥2 children	22 (71%)	14 (64%)	
Baby age (<i>n</i> = 53)			
< 6 months	17 (55%)	9 (41%)	.406
≥ 6 months	14 (45%)	13 (59%)	
BMI (<i>n</i> = 50) [§]			
Healthy weight [†]	6 (19%)	8 (42%)	.110
Overweight/obese [‡]	25 (80%)	11 (58%)	
Weight loss behaviour (<i>n</i> = 44) [‡]			
Pre-action stage	23 (85%)	10(59%)	.075
Action stage	4 (15%) ^{††}	7 (41%)	

*Significance $p < 0.05$;

[†]healthy BMI 20–24.9 kg/m²;

[‡]above healthy BMI >25 kg/m²;

[§]3 women did not answer this question;

[‡]9 women excluded because they felt their weight was healthy;

^{††}number of value in cell is <5.

Discussion

This study is the first to investigate readiness to change among Australian rural women with a history of GDM, which increases their risk of developing T2DM. The findings indicate a clear need to promote physical activity and weight loss in the postnatal period to this high risk group. The majority of women were in pre-action for physical activity and, of those who felt they needed to lose weight, for weight loss. This finding is consistent with pre-action in other populations. In a review of five cross-sectional studies of health behaviours in adults, including activity and weight loss, weight loss pre-action ranged between 34.1% and 68.2% and physical activity pre-action between 43.4% to 59%²¹.

The majority of women in pre-action for activity were also in pre-action for weight loss. This group of women were the

least engaged in diabetes risk behaviours. There is limited literature exploring lifestyle choices in women with a history of GDM. One Australian study involving 225 women with a history of GDM identified two-thirds of the sample (66.4%) were not achieving sufficient activity for health benefits and more than half (51.3%) were above their healthy weight range. Main barriers to physical activity were identified as lack of assistance with child care and insufficient time. Confidence to be active was lowest when these women were time pressured and tired²². Strategies to engage women who are in pre-action for diabetes risk reduction behaviours will need to explore individual barriers to change and target ambivalence^{12,23}. Further research is needed to test the efficacy of time-friendly interventions such as mail, telephone and electronic communications in this population, given that women in the postnatal period may be difficult to engage in intervention projects due to multiple commitments.



Table 3: Prevalence of readiness for weight loss behaviour

Variable	Weight loss (stage)		Fisher's exact test (2 sided) <i>p</i> *
	Not losing (Pre-action) <i>n</i> (%)	Losing (Action) <i>n</i> (%)	
All women (<i>n</i> = 44) ^{††}	33 (75%)	11 (25%)	–
Working status (<i>n</i> = 42) [§]			1.000
Working	9 (27%)	2 (18%) ^{¶¶}	
Not working	24 (73%)	7 (78%)	
Number of children (<i>n</i> = 44)			.287
1 child	9 (27%)	5 (45%) ^{¶¶}	
≥2 children	24 (73%)	6 (55%)	
Baby age (<i>n</i> = 44)			.162
< 6 months	19 (58%)	3 [‡] (27%)	
≥ 6 months	14 (42%)	8 (73%)	
BMI (<i>n</i> = 41) ^{‡‡}			.143
Healthy Weight [†]	3 (10%) ^{¶¶}	3 (30%) ^{¶¶}	
Overweight/Obese [¶]	28 (90%)	7 (70%)	
Physical activity behaviour			.075
Pre-action stage-matched	23 (70%)	4 (36%) ^{¶¶}	
Action stage	10 (30%)	7 (64%)	

*Significance $p < 0.05$;

†healthy BMI 20–24.9 kg/m²;

¶above healthy BMI >25 kg/m²;

§2 women did not answer this question;

‡3 women did not answer this question;

††9 women excluded because they felt their weight was healthy;

¶¶number of value in cell is <5.

In this study prevalence of pre-action for physical activity and weight loss behaviour was highest among mothers with larger families. Time commitments of having multiple children may prevent mothers from engaging in physical activity. In addition, exercising with one child is likely to be easier than with multiple children, especially when older children reach an age of not wanting to or not being able to sit in a pusher. The combination of low physical activity and being overweight creates a cycle of behaviour that is difficult for many women to break. These findings are of concern in light of research indicating that failure to lose weight in the first year postpartum is a predictor of longer term obesity in the mother^{24,25}. If weight gained during pregnancy is not lost by the time a woman falls pregnant again, it is likely that a cumulative weight gain effect will occur.

Our study found that women who were engaged in paid work (full or part time) were more active than those not working. This is surprising because working mothers would be expected to have less time to be physically active and 'no time' has previously been reported as a significant barrier to physical activity²⁶. However, employed women may value physical activity more than women not engaged in paid work. Employed women may also be better placed to negotiate partner support for and engagement in domestic chores and childrearing. Partner support has been found to be pivotal in mothers being able to prioritise activity as part of an already busy schedule²⁷. These issues warrant further study in the rural setting.

The fact that less women with a healthy weight reported that they thought their weight was healthy may reflect a lack of



knowledge of what constitutes a healthy weight by women wanting to return to their pre-pregnancy weight, or a cultural view that lower weight represents healthy weight. While the vast majority of postnatal women may require advice regarding weight loss, a smaller number may need to be advised about the benefits of weight maintenance. Similar numbers of women with a healthy BMI were in action and pre-action for activity. Regular physical activity should be encouraged on its own merit and not be confused with it being a weight management tool.

Women expressed a high level of motivation, optimism and confidence to prevent diabetes along with a high awareness of the importance of regular physical activity, healthy weight and healthy diet. This occurred despite the high level of pre-action for physical activity and weight loss. Despite this finding, a large proportion of the study sample in pre-action were in preparation stage for activity and weight loss (planning to do more physical activity in the next month and planning on losing weight in the next month). If this were the case, subsequent analysis may show a higher degree of engagement in diabetes risk reduction behaviours. However, previous research has indicated that women with a history of GDM, although concerned about their health and aware of their risk of developing diabetes, do not necessarily engage in risk reduction behaviour²⁸. It is generally felt that women maintain the healthy eating patterns established as part of management of GDM because the immediate priority is the health of their baby. Once an episode of GDM is over, maintenance of these behaviours may be more difficult.

Lifestyle change requires both motivation and readiness. The women in this study, while motivated, were not ready to adopt healthy lifestyle behaviours. Women may not see the risk of diabetes as of immediate concern, particularly when there are no symptoms associated with the early development of diabetes. In addition, the postnatal period is a time during which many changes occur in a woman's life. Competing responsibilities can alter sleeping habits, work schedules, eating patterns, exercise regularity and time allocation^{14,26}. This can challenge even the most committed mother of young children. Clearly, strategies to assist this

population to overcome barriers associated with behaviour change in the postnatal period are needed.

Despite a high level of motivation to prevent type 2 diabetes, one-third of the study sample felt they were either unsure or agreed that they would get diabetes even if they followed recommended lifestyle changes. This indicates a number of women may feel there is little incentive for them to increase activity and reduce weight if they are going to get diabetes anyway. An opportunity exists for health professionals to empower these women to believe they have a role in diabetes prevention, despite high risk.

The limitations of this study include a small sample size and reliance on self-reported physical activity, weight loss behaviour and weight/height. While self-report is a less reliable technique than objective measurement, it allows for easier data collection, at low cost, and does not alter the behaviour under study²⁹. However, previous research indicates that individuals over-report level of physical activity and height and under-report weight^{30,31}. Results presented are likely to be an underestimation of weight status and an overestimate of actual physical activity, suggesting that proportions of women in the overweight/obese category may be greater than reported, with lower proportions engaging in physical activity. While the sample is representative of this population, it may be underpowered to detect significant correlations (type II error).

As with other research projects conducted in communities where researchers and subjects are known to each other, a social desirability bias may have influenced the self-reported information. All subjects in this pilot study had previously attended the diabetes centre and knew the researchers. This could explain the high level of preparation for both weight loss and activity, because respondents may believe it preferable to answer that they are about to commence a behaviour rather than not seriously considering change. Readiness to change behaviour, as reported within stage of change, may not equate to actual readiness to modify behaviour.



The current study measured readiness to change activity but no measurement of amount of activity was performed. Hence, it is unclear from this study how much or what type of activity women were performing. In addition, no information about patterns of lactation, educational status or income level was obtained. These data may have helped to explain patterns of readiness to engage in healthy lifestyle behaviour. Studies with larger samples in rural populations may be able to further investigate these issues.

Overall these results represent the views of this group of rural women with a history of GDM. The study adds to the limited information available on this population group and provides insight into the health behaviours and beliefs about diabetes prevention following an episode of GDM. Encouraging individuals at high risk of chronic disease to change lifestyle behaviours is often difficult and, therefore, understanding what factors these women believe to be important in diabetes prevention may help in the development of more effective and efficient interventions. However, larger cohort studies are needed to obtain a better estimate of the impacts of GDM and to fully understand the issues, readiness to change, levels of engagement and interventions that may be effective in this vulnerable population in rural Victoria.

Conclusion

The results reported here demonstrate that the majority of rural women with a history of GDM in northern Victoria were not ready to actively prevent diabetes. More than half were not active and three-quarters were overweight. Although most respondents were aware of how to prevent diabetes, only half were involved in some diabetes risk reduction behaviour. The reasons are likely to be multifactorial. In addition to child-care and partner support programs, there is need for programs designed to increase readiness to change in this vulnerable group. Successful health interventions will need to target ambivalence to behaviour change, while keeping in mind this population have multiple commitments and may have difficulty being

able to prioritise health promotion and disease prevention activities. The challenge remains to design interventions that do not add to the already busy life of a mother with young children.

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Appendix I

Stage of Change Questionnaire for exercise (for weight loss substitute losing weight for physical activity)

Please circle the answer that best describes your current level of physical activity.

For the purposes of this questionnaire, being physically active means doing activities such as walking, playing sport, cycling, or dancing for at least 20 minutes, 3 to 5 times a week.

1. I am not physically active and I don't plan on doing any physical activity in the near future	Yes = Pre-contemplation
2. I am not active at the moment but I am thinking about being more active	Yes = Contemplation
3. I am preparing to do more activity and intend to start in the next month	Yes = Preparation
4. I have been physically active for less than 6 months	Yes = Action
5. I have been physically active for more than 6 months	Yes = Maintenance

Adapted from Marcus et al [19].

Effectiveness of Self-Management Training in Type 2 Diabetes

A systematic review of randomized controlled trials

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OBJECTIVE — To systematically review the effectiveness of self-management training in type 2 diabetes.

RESEARCH DESIGN AND METHODS — MEDLINE, Educational Resources Information Center (ERIC), and Nursing and Allied Health databases were searched for English-language articles published between 1980 and 1999. Studies were original articles reporting the results of randomized controlled trials of the effectiveness of self-management training in people with type 2 diabetes. Relevant data on study design, population demographics, interventions, outcomes, methodological quality, and external validity were tabulated. Interventions were categorized based on educational focus (information, lifestyle behaviors, mechanical skills, and coping skills), and outcomes were classified as knowledge, attitudes, and self-care skills; lifestyle behaviors, psychological outcomes, and quality of life; glycemic control; cardiovascular disease risk factors; and economic measures and health service utilization.

RESULTS — A total of 72 studies described in 84 articles were identified for this review. Positive effects of self-management training on knowledge, frequency and accuracy of self-monitoring of blood glucose, self-reported dietary habits, and glycemic control were demonstrated in studies with short follow-up (<6 months). Effects of interventions on lipids, physical activity, weight, and blood pressure were variable. With longer follow-up, interventions that used regular reinforcement throughout follow-up were sometimes effective in improving glycemic control. Educational interventions that involved patient collaboration may be more effective than didactic interventions in improving glycemic control, weight, and lipid profiles. No studies demonstrated the effectiveness of self-management training on cardiovascular disease-related events or mortality; no economic analyses included indirect costs; few studies examined health-care utilization. Performance, selection, attrition, and detection bias were common in studies reviewed, and external generalizability was often limited.

CONCLUSIONS — Evidence supports the effectiveness of self-management training in type 2 diabetes, particularly in the short term. Further research is needed to assess the effectiveness of self-management interventions on sustained glycemic control, cardiovascular disease risk factors, and ultimately, microvascular and cardiovascular disease and quality of life.

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Diabetes self-management training, the process of teaching individuals to manage their diabetes (1), has been considered an important part of clinical management since the 1930s (2). The goals of diabetes education are to optimize metabolic control, prevent acute and chronic complications, and optimize

quality of life while keeping costs acceptable (3). One of the goals of Healthy People 2010 is to increase to 60% (from the 1998 baseline of 40%) the proportion of individuals with diabetes who receive formal diabetes education (4). There are significant knowledge and skill deficits in 50–80% of individuals with diabetes (5), and ideal glycemic control ($HbA_{1c} < 7.0\%$) (6) is achieved in less than half of persons with type 2 diabetes (7). The direct and indirect costs of diabetes and its complications were estimated to be \$98 billion in 1997 (8), although the cost of diabetes education as a discrete component of care has not been defined.

A large body of literature exists on diabetes education and its effectiveness, including several important quantitative reviews showing positive effects. However, these reviews aggregated studies of heterogeneous quality (9–11) and types of interventions (9,10) and do not identify the most effective form of diabetes education for specific populations or outcomes. Moreover, educational techniques have evolved since these reviews (9–11) and have shifted from didactic presentations to interventions involving patient “empowerment” (12).

The objective of this study was to systematically review reports of published randomized controlled trials to ascertain the effectiveness of self-management training in type 2 diabetes, to provide summary information to guide diabetes self-management programs and future quantitative analyses, and to identify further research needs.

RESEARCH DESIGN AND METHODS

Search methods

The English-language medical literature published between January 1980 and December 1999 was searched using the MEDLINE database of the National Library of Medicine, the Educational Resources Information Center (ERIC) database, and the Nursing and Allied

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Abbreviations: SMBG, self-monitoring of blood glucose.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Health database (commenced in 1982). The medical subject headings (MeSH) searched were "Health Education" combined with "Diabetes Mellitus," including all subheadings. Abstracts were not included because they generally contain insufficient information to assess the validity of the study by the criteria described below. Dissertations were also excluded because the available abstracts contained insufficient information for evaluation and the full text was frequently unavailable. Titles of articles extracted by the search were reviewed for their relevance to the effectiveness of diabetes education, and if potentially relevant, the full-text article was retrieved. Because automated databases are incomplete (13–15), the following journals, believed to have the highest relevance, were searched manually: *Diabetes Care*, *Diabetes Educator*, *Diabetes Research and Clinical Practice*, *Diabetologia*, and *Diabetic Medicine*.

Study selection

Only randomized, controlled trial reports were selected because this type of study design generally supports maximum validity and causal inference (16). We reviewed only studies in which all or most subjects had type 2 diabetes. If the type of diabetes was unclear, then the study was included when the mean age was >30 years. It was believed that the educational techniques and social influences (especially family and peers) relevant to children and adolescents with either type 1 or type 2 diabetes were sufficiently different to warrant a separate review. To examine as broadly as possible the effectiveness of diabetes education, we included studies of subjects with type 2 diabetes >18 years of age, with any degree of disease severity and with any comorbidity. Interventions in all settings were included. Education could be delivered by any provider type, could involve any medium (written, oral, video, computer), could be individual- or group-based, and could be of any duration and intensity. Studies with multi-component interventions were included only if the effects of the educational component could be examined separately.

Self-management training interventions were classified into one of the following categories by primary educational focus: knowledge or information; lifestyle behaviors, including diet and physical activity; skill development, including skills to improve glycemic control such as self-

Table 1—Assessment of internal validity based on Cochrane Collaboration Criteria (20)

Type of bias	Definition
Selection bias	Systematic differences in control and intervention groups at baseline To avoid requires randomization and no significant differences between baseline variables in control and intervention groups, or adequate statistical consideration of potential confounders if baseline differences exist
Performance bias	Systematic differences in care provided to control and intervention groups, apart from the intervention being evaluated To avoid requires no evidence of contamination or cointervention, including no additional contacts with researcher or providers for the intervention group compared with the control group
Attrition bias	Systematic differences between study groups in withdrawals from the study To avoid requires attrition <20% of total n, or dropouts must resemble completers in baseline characteristics
Detection bias	Systematic differences in outcomes assessment between study groups To avoid requires blinding for any outcome subject to assessor interpretation

monitoring of blood glucose (SMBG), as well as skills to prevent and identify complications (e.g., foot care); and coping skills (to improve psychosocial function), including interventions using empowerment techniques or promoting relaxation or self-efficacy. Studies with a focus on knowledge or information were subclassified by primary type of educational approach: didactic or collaborative. Didactic education occurred when the patient attended to the information but did not interact with the instructor or participate actively in teaching sessions. Collaborative education occurred when the patient participated actively in the learning process, including group discussions or hands-on practice, or when teaching techniques included empowerment (17), individualized goal-setting, biofeedback, or modeling. The other three categories of lifestyle, skill development, and coping skills education were generally all collaborative to some extent; therefore, these types of interventions were not subclassified.

Data extraction

Data extracted from eligible studies included descriptive information, analysis methods, and results. Extraction was not blinded, because there is no evidence that blinding results in a decrease in bias in the conduct of systematic reviews and meta-analyses (18,19).

Validity assessment

Quality assessment was determined by what was reported in each article, and internal validity was assessed using Cochrane methodology (20) for four types of bias (Table 1). These biases are believed to have significant effects on measured outcomes in intervention studies (21), and if present in an article, note was made in the tables.

These criteria for bias were modified from those used in Cochrane methodologies, because not one study in the literature reviewed fulfilled all definitions for the absence of bias. To avoid selection bias, ideally one requires concealment of the allocation schedule so that neither patient nor researcher can influence assignment sequence (22). However, because most studies in this review did not comment on method of allocation, beyond stating that subjects were randomized, allocation concealment was not used as a necessary criteria for the absence of selection bias. To avoid performance bias, blinding of patients to the intervention is required, which is impossible in diabetes education studies; therefore, patient blinding was not used as a validity criterion. Attrition was noted as a potential bias when more than 20% of initially enrolled subjects dropped out before data collection, and dropouts were not compared or were not found equivalent to completers at baseline.

External validity was also assessed

and was considered adequate if the accessible population reasonably represented the target population and study subjects were either a random sample of the accessible population or consecutively referred patients, or if no significant differences between participants and nonparticipants were demonstrated at baseline. Studies with populations that consisted of volunteers, that were convenience samples, or were otherwise selected by the researchers may not be generalizable to target populations; therefore, the nature of these study populations is indicated in the tables.

Outcomes

Outcomes are summarized in a qualitative fashion to 1) aid in generating hypotheses, 2) detail the categorization of variables for future quantitative syntheses (23), and 3) portray the heterogeneity of the populations, interventions, methodology, study quality, and outcomes in this literature. It was believed that derivation of a single summary statistic would not be meaningful in determining what interventions are effective in what populations. The power of statistical tests of homogeneity is low, and failure to reject a hypothesis of homogeneity does not prove that studies are sufficiently similar to be aggregated (24).

We classified outcomes as 1) process measures including knowledge, attitudes, and self-care skills; 2) lifestyle behaviors, psychological outcomes, and quality of life; 3) glycemic control; 4) cardiovascular disease risk factors; and 5) economic measures and health service utilization. Because a study can have multiple outcomes, each study can be listed one or more times in the results tables, which are classified by outcome. Glycated hemoglobin measures are presented as percentage change in the text and the figure, due to the measurement of different glycated components of hemoglobin in different studies as well as the variability of measurement between laboratories and over time (25).

RESULTS— A total of 72 discrete studies, published in 84 articles, were identified. These studies are heterogeneous with respect to patient population, educational intervention, outcomes assessed, study quality, and generalizability (Tables 2–6). Review of this literature reveals a number of important generaliza-

tions concerning the components and determinants of effective interventions and the outcomes most conducive to improvement.

Process measures

Knowledge. Most studies measuring changes in diabetes knowledge demonstrate improvement with education (Table 2) (26–46), including those with follow-up of 6–12 months after the last intervention contact (28–30,36,40,43). Seven studies demonstrated improved knowledge for both the intervention and control groups (47–53), suggesting possible contamination due to the infeasibility of blinding participants. A number of studies demonstrated that regular reinforcement or repetition of the intervention seemed to improve knowledge levels at variable lengths of follow-up: Bloomgarden et al. (34) (nine visits in 18 months), Korhonen et al. (35) (one visit every 3 months for 12 months), Campbell et al. (29) (regular reinforcement with visits and telephone calls over 12 months), and Rettig et al. (46) (12 visits in 12 months). Knowledge was measured using a variety of instruments, often specifically developed for the study and lacking in documented reliability and validity (26,30,32,33,35,39,44,47,52,54–56).

Self-care. Several studies observed increased frequency of, or more accurate SMBG, demonstrated by a decreased discrepancy between measurement by the patient and health-care personnel (40,45,57–59) (Table 2). Several studies examined the relationship between skills teaching and glycemic control. Although three of these studies (40,57,60) noted an increase in frequency of SMBG, no corresponding improvement in HbA_{1c} was found. Wing et al. (61) taught adjustment of diet and physical activity in conjunction with SMBG, but the patients in this study failed to show improved glycemic control at 1 year.

Several studies examined interventions focusing on foot lesions with mixed results. Litzelman et al. (62) noted a decrease in serious foot lesions at 1 year after an intervention consisting of group education, with three follow-up visits, provider guidelines, and chart reminders. Other studies failed to demonstrate improvements with interventions (41,46,63). Malone et al. (64) found a significant decrease in foot ulcer and ampu-

tation rates, although this study had significant methodological inadequacies.

Lifestyle behaviors

Most studies that examined dietary changes were positive for self-reported changes, including improvements in dietary carbohydrate or fat intake (38,39,65–70) (Table 3), a decrease in caloric intake (39,67), and an increase in consumption of lower glycemic-index foods (71). A few studies demonstrating improved dietary changes found corresponding improvements in weight (38,66,72) or glycemic control (31). Only two studies failed to show improvement in diet: one had an 18-month follow-up and an intervention delivered every 3 months (35), and the other (73) noted improved dietary habits during the intervention but no significant difference at 6 months.

Studies measuring physical activity outcomes had variable results. Hanefeld et al. (65) demonstrated an increase in activity at 5 years with a didactic intervention. Among studies with shorter follow-up duration, Wood (54) noted an increase in physical activity at 4 months, Glasgow et al. (74) found an increase in the number of minutes of activity 3 months after an intensive intervention, and Wierenga (75) found improved physical activity after five intervention sessions at 4 months. Five studies found no changes in physical activity compared with control groups (30,40,69,76,77). It is unclear what factors might account for success in some studies and not in others.

Psychological and quality-of-life outcomes

Four studies examined psychological outcomes (Table 3) (33,40,74,78); improvements were noted in problem solving (74) and anxiety levels (33). Quality of life was examined in three studies. Kaplan et al. (79) noted an increase in quality of life at 18 months for an intervention subgroup that received intensive counseling on both diet and physical activity. Two studies of brief interventions failed to demonstrate improved quality of life (60,67).

Glycemic control

Studies that focused on glycemic control are described in Table 4 and Fig. 1. Both control and intervention study groups tended to have improved glycated hemoglobin measures (29,31,32,36,48,49,60,

Table 2—Effect of self-management training on knowledge, attitudes, and self-care skills

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
1. Didactic, knowledge, and information interventions				
33	n = 60; F/U immediate, 4 weeks; ?age	I: Four weekly group sessions; individual as needed C: Started same education 4 weeks later	Increased knowledge I vs. C at 4 weeks, P < 0.01	No BL statistics; I more visits than C Attrition 29%, dropouts not equal to completers at BL Low participation rate, but NSD participants and nonparticipants
34	n = 345; F/U immediate; 58 years	I: Nine multimedia education classes over 1.5 years C: Usual care	Increased knowledge I vs. C, P = 0.0073 NSD behavior score; NSD foot lesions	No mention blinding assessor Low participation rate; nonparticipants older, more males
35	n = 77; F/U 6–18 months from BL; 33 years	I: 5-day IP teaching: didactic, individual F/U q3 months, phone access; instruction in self-adjustment insulin C: 5-day IP “traditional” education + written information; 3 × 1.5-h sessions; q3 months F/U	Increased knowledge both C and I, I > C, P < 0.01 at 12 months Increased urine testing I and C (NSD between groups) Knowledge not correlated with BS control	No BL comparison statistics No attrition information No blinding for diet history Low recruitment rate and no information on nonparticipants
42	n = 30; F/U immediate; 59 years	I: 15-min video featuring local HCW in Spanish C: Pretest only, then viewed video	Increased knowledge in I, effect size moderate (0.61)	No BL comparison of demographics Unclear if assessor blinded Convenience sample I had no pretest to avoid bias from retesting
47	n = 51; F/U 12 months from BL; 53 years	I: Three weekly didactic, small group sessions q4 months + q2 months visit with doctor C: Visit with doctor q2 months	NSD knowledge between groups	I more visits than C No information on participation rates
51	n = 40; F/U immediate; 60 years	I: 1-h individual education based on patient’s priorities C: 1 h individual education based on educator’s priorities	Increased knowledge both groups, P < 0.0001, NSD between groups	Unclear if assessor blinded Consecutively referred patients Type of DM unclear
52	n = 111; F/U 2–3 months; 56 years	I: One-page drug information sheet given to patients attending clinic C: Usual care	Both groups increased knowledge; NSD between groups	
57	n = 31; F/U 1 week; HbA _{1c} F/U 2 months; 65 years	I: Four weekly TC after hospital discharge: identify deficits and teach C: No TC or other contact	I more frequent SMBG and increased hypoglycemic prevention, P < 0.05	I more contact than C Unclear if assessor blinded No information on nonparticipants
2. Collaborative, knowledge, and information interventions				
26	n = 80; F/U 6 months from BL; 53 years	I: Group sessions: didactic and discussions; no details of duration or frequency; F/U every 3 months C: Care at general medical clinic every 3 months	Increased knowledge in I vs. C, P < 0.01	Attrition 25%, no comparison dropouts to completers
27, 28	n = 532; F/U 12–14 months; 57 years	I: Average 2.4 sessions × 1.5 h over 2 months + home visit, TC F/U, contracting, skill exercises, goal-setting; over 26 months C: Usual care	Achievement of some knowledge, skill, and self-care objectives in I vs. C, P < 0.05	I more visits than C Attrition 51%, differences dropouts and completers No blinding assessor Low participation rate
29	n = 238; F/U 3, 6, 12 months from BL; 56 years	I-1: 13 individual sessions in 12 months I-2: Three-day interactive course + F/U 3 and 9 months + two individual sessions I-3: Six or more individual sessions based on cognitive behavior theory, TC F/U over 12 months C: 2 × 1-hour group education	Increased knowledge I-3 at 3 and 6 months, P < 0.05	BL differences: I-2 better educated, I-1 longer duration DM I more visits than C Dropouts longer duration DM than completers Unclear if study population represents target population
30	n = 46; F/U immediate, 6 months; 66 years	I: 8 × 2-hour small group sessions over 3 months; problem- and participant-focused C: One-day didactic teaching	Increased knowledge at 6 months I vs. C, P < 0.05	I more visits than C More C excluded due to poor control No mention blinding assessor Nonparticipants older and heavier
32	n = 174; F/U 4–6 months; 57 years	I-1: Computer knowledge assessment program (KAP) + interactive computer teaching (60 min) I-2: KAP (20–40 min) + feedback I-3: KAP only C: No intervention	Increased knowledge all I, P < 0.05 (within group)	Randomization by year and birth month (no details given) I more contact than C NIDDM results reported here (49% of total study population IDDM)

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Table 2—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
40, 60	n = 558; F/U 6 months; 45 years	I-1: Collaborative education by HCW, 3 h/week × 4 weeks I-2: Same education, led by fellow patient C: No intervention I based on Fishbein and Ajzen Health Belief Model	Increased knowledge both I, $P < 0.001$; Increased DM locus of control, $P < 0.001$ Improved attitude and frequency SMBG both I, $P < 0.05$ Increased self-adjustment of insulin both I, $P < 0.01$	Hospitals randomized I more visits than C Uncertain blinding assessor
44	n = 24; F/U immediate; 35–65 years	I: 1-h computer-based drill with feedback including explanation of correct answer C: As for I, but right/wrong feedback only I and C received 14-min instructive video before computer drill	Increased knowledge in I vs. C, $P = 0.005$ NSD attitudes toward the drill	No BL comparisons Volunteer study population
46	n = 471; F/U 6, 12 months from BL; 52 years	I: Home visits, teaching based on needs assessment, maximum 12 visits C: Usual care	Increased knowledge at 6 months, $P = 0.001$ NSD foot appearance score at 6 months Increased medication skills at 6 months, $P = 0.04$ and urine testing, $P = 0.01$	Attrition 20%, no comparison dropouts to completers 70% of eligible participated
48	n = 82; F/U 6 months from BL; 56 years	I-1: 11 × 2-h didactic weekly course + 1 individual session I-2: 11-week course + three individual sessions: barriers and support C: Usual care	Increased knowledge for all three groups; NSD between groups NSD health locus of control	No BL statistics comparing groups I more visits than C Attrition 40%, no comparison dropouts to completers Volunteer study population
50	n = 40; F/U 3 months; 57 years	I: CAI, 4 × 1-h sessions: didactic, some feedback and testing C: Didactic group teaching; 4 × 3-h	Increased knowledge both groups; NSD between groups	No BL group comparison statistics Low participation rate, no information on nonparticipants or dropouts
54	n = 107; F/U 1, 4 months; 60 years	I: 2 × 2-h group didactic + practice + feedback + usual care C: Usual care: individual education based on perceived patient need Both in IP setting	Increased compliance to insulin injection time for I at 4 months, $P = 0.05$	Randomized by hospital number No blinding assessor No information on participation rates
55	n = 41; F/U 2 months; 60 years	I-1: Three-day program + group session with pharmacist I-2: Three-day program + individual session with pharmacist; TC F/U C: Standard center 3-day education program	NSD change in knowledge between I and C or between I-1 and I-2 Improved attitudes/perceptions towards medications in I vs. C, $P < 0.05$ NSD attitudes to SMBG NSD overall knowledge	No BL comparison I more contact than C 23% had unusable data for SMBG
56	n = 53; F/U 3–5 weeks; 63 years	I: 2 × 5-min TC in 5 weeks; focus knowledge and skills C: 2 × 15-min individual visits in 5 weeks, same content Both groups individual education immediately before intervention	Frequency SMBG I > C, $P < 0.0001$	Attrition 25%, no comparison dropouts to completers
59	n = 60; F/U 3 months from BL; 55 years	I: Three-day group education, with F/U of four TC and one home visit; reinforce knowledge and skills C: Three-day group education	NSD knowledge between groups Increased self-care competency in I vs. C, $P = 0.003$	I more contact than C Unclear if study population represents target population
98	n = 22; F/U 32 weeks from BL; 61 years	I: Weekly to biweekly home visits: nutrition, exercise, foot care, SMBG; by nursing students C: Usual care	NSD knowledge between groups Increased self-care competency in I vs. C, $P = 0.003$	Attrition 24%, no comparison dropouts to completers No mention blinding assessor Unclear if study population represents target population
99	n = 56; F/U 6 months; 64 years	I: Monthly × 6 group sessions: behavior modification (contracts, feedback), and general knowledge C: Usual care	Increased knowledge at 6 months, $P = 0.0003$	I more contact than C Attrition 32%, no comparison dropouts to completers Participation rate 37%, no comparison participants to nonparticipants
108	n = 280; F/U 6 months; 55 years	I: Education on importance of eye examination: booklet, video; one interactive TC C: Usual care	Increased rate of retinal examination in I (OR = 4.3, 95% CI 2.4–7.8)	

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Table 2—Continued

Reference	n, F/U interval, mean age	Interventions	Outcomes	Comments
3. Lifestyle interventions				
31	n = 40; F/U 6 months from BL; 35 years	I-1: Lunch demonstrations I-2: Videotape education C: Dietitian instruction and written information Three visits total for all groups over 6 months	Increased knowledge in I-1 and I-2, P < 0.001	No mention blinding assessor Study population selected by researchers; low participation rate Type of diabetes unclear ("insulin dependent")
36	n = 87; F/U 12 months from BL; 56 years	I: Five group sessions over 6 months, focus on weight loss C: Individual education on weight loss by dietitian; 3 or more visits in 12 months	Increased knowledge I > C, P < 0.001	
37	n = 105; F/U 6 months; 58 years	I: Diet guide: guidelines, nutrition goals, food logs C: Traditional exchange list teaching Both groups taught at 3 × 2.25-h weekly sessions	NSD diet principals; Increased applied nutrition knowledge I > C, P < 0.01 Attitude to life and diet, and diet knowledge improved I and C, P < 0.05	Attrition 21%, no information on dropouts Unclear how patients recruited
38	n = 32; F/U immediate; 53 years	I: Two sessions: dietitian and CAI C: 2 × 30-min sessions: dietitian only Teaching for both over ~1 month	Increased exchange list knowledge for I, P < 0.05; NSD C	No BL statistics Unclear if blinding assessor Type of DM unclear
39	n = 105; F/U immediate, 12 months; 45 years	I: Interactive computer program on diet; 90 min/month over 6 months C: Wait listed for I Both groups received 5 days of teaching	Increased knowledge for I, P < 0.0001; NSD for C	I more contact than C Attrition appears to be 76% at 12 months F/U No comparison dropouts to completers No mention blinding assessor No information on patient recruitment Crossover design
43	n = 201; F/U 6 months; 53 years	I: Culturally appropriate flashcards: diet, SMBG; delivered by lay HCW C: Usual care	Increased knowledge, self-care in I vs. C, P < 0.05	I more contact than C Intensity of intervention unclear
49	n = 41; F/U 6 months; 61 years	I: Psychologist-led group sessions on PA and diet C: Didactic lectures on diet and DM Both groups 10 × 1-h sessions over 6 months	Increased knowledge for both groups, P < 0.05, NSD between groups	Dropouts (22%) had higher mean BS; equal number dropouts I and C Low participation rate, no information on nonparticipants
75	n = 66; F/U 4 months; 30–86 years	I: 5 × 90-min weekly sessions by nurse: diet, PA, barriers, social and group support C: No information on care received	Improved health attitudes I vs. C, P = 0.015 NSD perceptions of health relating to DM	No BL statistics Volunteer study population Number of visits uncertain
76	n = 64; F/U 3, 6 months from BL; 62 years	I: 12 × 1.5-h weekly (didactic) sessions, then 6 × 1.5-h biweekly participatory sessions; based on social action theory C: One didactic class and two mailings	Increased nutrition knowledge at 3 months; NSD from BL at 6 months	I more visits than C More C dropouts, no comparison dropouts to completers Volunteer study population
80	n = 40; F/U 2, 5 months from BL; 59 years	I: 3 × 1.5-h individual learning activity packages with diet information, goals, activities C: 3 × 1.5-h didactic lectures	Increased knowledge for I at 5 months, P < 0.05	Attrition 23%, no comparison dropouts to completers Volunteer study population from DM education program
83	n = 596; F/U immediate, 6 months; 51 years	I: More nutrition content, follow food pyramid C: Usual education, given meal plan Both I and C: 5 × 2-h weekly group sessions	NSD attrition, knowledge, self-care between choice/no choice groups NSD knowledge, self-care between I and C	Randomized into choice/no choice of program, then I and C Attrition 28%, dropouts younger, more male No mention blinding assessor Physician-referred patients or volunteers
95	n = 120; 12 months from BL; 61 years	I: Group education (diet, PA, BS control) q3 months × 4 C: Usual care	Increased knowledge in I, P < 0.001	I more contact than C Unclear if study population represents target population

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Table 2—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
4. Skills teaching interventions				
41	n = 70; F/U 6 months; 59 years	I: 9 h over 4 weeks: participatory foot care based on cognitive motivation theory C: Usual DM teaching: 14 h didactic/3 days, including 1 h foot care	Increased knowledge both groups at 6 months, I > C, P < 0.001 Increased compliance foot care routines at 6 months, I > C, P = 0.012 Compliance correlates with decreased foot problems, P = 0.002 Decreased foot problems both I and C, NSD between groups at 6 months Compliance correlates with decreased foot problems, P = 0.002	Volunteer study population
45	n = 34; F/U 8 weeks; 37 years	I: Self-study course on self-control and self-management SMBG, over 4 weeks C: Usual care	Increased knowledge and skills for I > C, P < 0.01 Increased SMBG goal adherence rate more for I than C, P < 0.01	No BL statistics Attrition 26%, no comparison dropouts to completers Community recruitment; participants self-selected Type of DM unclear No mention blinding assessor
53	n = 50; F/U 1 month; 73 years	I: 24-min instructional video on technique SMBG C: Group didactic instruction on technique SMBG	Increased knowledge both groups, NSD between groups No improvement SMBG technique I or C	
58	n = 30; F/U immediate; 55 years	I: SMBG instruction for 30 min by educator C: Self-instruction SMBG for 30 min	Decreased error BS measurement in I, P < 0.01	
62	n = 395; F/U 12 months from BL; 60 years	I: Group foot education with F/U ×3 over 3 months; chart reminders for providers, provider guidelines C: Usual care	Decreased serious foot lesions in I at 1 year, P = 0.05 I had more appropriate foot care behaviors, P < 0.05 Physicians examined I feet more often at office visits, P < 0.001	Randomized by practice team I more contact than C Low participation rate; no information on nonparticipants
63	n = 50; F/U 6 months; adult	I: Additional participatory teaching on foot care C: Usual education, with routine, didactic foot education Both groups: 5 days of OP DM education	Self-care practices increased both groups, no statistics Increased knowledge foot care for C only, P = 0.02 NSD physical assessment feet I or C	Randomized by week entering program; no BL comparisons Attrition 35% I, 44% C, no comparison dropouts to completers No mention blinding assessor No demographic data; type of DM unclear
64	n = 203; F/U 13 months I, 9 months C; ?age	I: 1-h didactic group education on foot care C: No education	Decreased foot ulcer rate, P < 0.005 Decreased amputation rate, P < 0.025 NSD infection rate	Randomized on SSN No information on dropouts No mention blinding assessor No information on nonparticipants Type of DM unclear
5. Coping skills interventions				
85	n = 64; F/U 6 weeks; 50 years	I: 6 × 2-h weekly group sessions: patient empowerment, goal-setting, problem solving, stress management C: Wait listed	Increased 4/8 self-efficacy subscales, between group difference, P < 0.02	No BL comparisons; 18 patients not randomly assigned I more contact than C Volunteer study population 64% DM2 HbA _{1c} measured immediately after program for C, 6 weeks after for I
86	n = 32; F/U 2 years; 68 years	I-1: Six weekly sessions + 18 monthly support group sessions: coping, discussion, education I-2: Six-week sessions only; wait list for support group C: Usual care	Increased knowledge maintained for I-1 at 2 years, P < 0.05	C is nonrandomized comparison group More visits for I-1 > I-2 > C No information on attrition Unclear if study population represents target population Type of DM unclear

BL, baseline; BS, blood sugar; BP, blood pressure; C, C-1, C-2, control groups; CAI, computer-assisted instruction; CHO, carbohydrate; D/SBP, diastolic/systolic blood pressure; DM, diabetes mellitus; DM2, type 2 diabetes; FBS, fasting blood sugar; F/U, follow-up; HCW, health-care worker; I, I-1, I-2, I-3, intervention groups; IP, inpatient; NSD, no significant difference; OP, outpatient; PA, physical activity; q, every; RN, registered nurse; SD, significant difference; TC, telephone call.

66,68,74,78,80–83) (Fig. 1). All studies were unblinded. In 14 studies, an improvement was noted in glycemic control in the intervention group compared with the control group (26,28,32,33,47,48,50,

65,71,76,79,84–87). Percentage change in glycosylated hemoglobin ranged from –26 to +4% in the intervention groups and from –33 to +15% in the control groups. In three studies, glycosylated hemoglobin de-

creased more in the control group (61,80,83), although the difference was significant in only one study (80).

Length of follow-up after completion of an intervention seemed to have a major

Table 3—Effect of self-management training on lifestyle behaviors, psychological outcomes, and quality of life

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
1. Didactic, knowledge, and information interventions				
33	n = 60; F/U immediate, 4 weeks; ?age	I: Four weekly group sessions: individual as needed C: Started same education 4 weeks later	Decreased anxiety at 4 weeks I vs. C, $P < 0.05$ NSD depression score	No BL statistics I more visits than C Attrition 29%, dropouts not equal completers at BL Low participation rate, but NSD participants and nonparticipants
35	n = 77; F/U 6 to 18 months from BL; 33 years	I: Five days IP teaching: didactic, individual F/U q3 months, phone access; instruction in self-adjustment insulin C: Five days IP “traditional” education + written information; 3 × 1.5-h sessions; q3 months F/U	NSD diet adherence at 18 months	No BL comparison statistics No attrition information No blinding for diet history Low recruitment rate and no information on nonparticipants
65, 109	n = 1,139; F/U 5 years; 46 years	I-1: Didactic individual and group sessions q3 months: focus on diet, PA, smoking, BP, and BS control I-2: I-1 + clofibrac acid C: Usual care at DM clinics; q3–4 months	Increased polyunsaturated fats in I vs. C, $P < 0.01$ Increased PA in I vs. C, $P < 0.01$	No mention blinding assessor Low participation rate, no information on nonparticipants Clofibrac acid arm double-blinded
2. Collaborative, knowledge, and information interventions				
30	n = 46; F/U immediate, 6 months; 66 years	I: 8 × 2-h small group sessions over 3 months; problem- and participant-focused C: One day didactic teaching	NSD exercise	I more visits than C More C excluded due to poor control No mention blinding assessor Nonparticipants older and heavier
40, 60	n = 558; F/U 6 months; 45 years	I-1: Collaborative education by HCW, 3 h/week × 4 weeks I-2: Same education, led by fellow patient C: No intervention I based on Fishbein and Ajzen Health Belief Model	NSD hypoglycemic reactions, anxiety, PA	Hospitals randomized I more visits than C Uncertain blinding assessor
54	n = 107; F/U 1, 4 months; 60 years	I: 2 × 2-h group didactic + practice + feedback + usual care C: Usual care: individual education based on perceived patient need Both in IP setting	Increased exercise I vs. C at 1 and 4 months, $P = 0.05$	Randomized by hospital number No binding assessor No information on participation rates
98	n = 22; F/U 32 weeks from baseline; 61 years	I: Weekly to biweekly home visits: nutrition, exercise, foot care, SMBG; by nursing students C: Usual care	NSD food assessment, 3-day dietary recall, functional health status between groups	Attrition 24%, no comparison dropouts to completers No mention blinding assessor Unclear if study population represents target population
3. Lifestyle interventions				
31	n = 40; F/U 6 months from BL; 35 years	I-1: Lunch demonstrations I-2: Videotape education C: Dietitian instruction and written information Three visits total for all groups over 6 months	Decreased CHO variation in I-1 and I-2, $P < 0.01$	No mention blinding assessor Study population selected by researchers; low participation rate Type of diabetes unclear (“insulin dependent”)
38	n = 32; F/U immediate; 53 years	I: Two sessions: dietitian and CAI C: 2 × 30-min sessions: only dietitian Teaching for both over approximately 1 month	Decreased % fat intake I, $P < 0.005$; NSD C	No BL statistics Unclear if blinding assessor Type of DM unclear
39	n = 105; F/U immediate, 12 months; 45 years	I: Interactive computer program on diet; 90 min/month over 6 months C: Wait listed for I Both groups received 5 days teaching	Decreased caloric and fat intake for those in I with initial high intake, $P < 0.05$	I more contact than C Attrition appears to be 76% at 12 months F/U, no comparison dropouts to completers No mention blinding assessor No information on patient recruitment Crossover design
66	n = 148; F/U 6 months from BL; 55 years	I: Advice to decrease fat to <30% total calorie intake C: Advice to decreased CHO to <40% total calorie intake Both individual counseling by dietitian, three home visits	Decreased fat and cholesterol intake, increased CHO for I, between group difference, $P < 0.001$	

Continued on following page

Table 3—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
67, 68, 104	n = 206; F/U 12 months from BL; 62 years	I: Single visit: focus on diet; goal-setting, interactive video on barriers; F/U q3 months C: Usual care q3 months	Improvement in I vs. C at 12 months for food habits, 4-day food record, kcal/day, % calories from fat, P < 0.05	Unclear if food record reviewers blinded Low participation rate; participants differ from nonparticipants
69, 82, 89, 103	n = 86; F/U 15, 27 months from BL; 53 years	I: Six individual visits at 2-month intervals: intensive therapy for weight, BS control, diet, PA; then q3 months visits C: Usual care q2–3 months Both groups got 3 visits/3 months basic education before randomization	Fat intake <30% of total energy, I > C at 15 months, P < 0.05 NSD energy intake NSD physical activity, Vo _{2max} at 15 months	I more visits than C No mention blinding assessor No information on nonparticipants
70	n = 75; F/U 12 months from BL; 61 years	I: Educational videos, personal and family support q2 weeks for 6 months + 3 h counseling by dietitian C: Review session × 3	Decreased self-reported fat intake, P = 0.0002 NSD self-reported total food or fiber intake	I more contact than C
71	n = 60; F/U 12 weeks from BL; 55 years	I: Individualized advice on low glycemic index foods C: Standard, individualized diet advice	Consumption of lower glycemic index foods I > C, P < 0.01	No mention blinding assessor Unclear how much intervention time
72	n = 78; F/U 2 months; 42–75 years	I-1: 5 × 2-h weekly education: calories, fat, fiber I-2: I-1 + goal setting, problem-solving, feedback C: Wait listed for I	Decreased calories and % fat F/U for I-2 at immediate and 2 months, P < 0.01 Decreased calories for I-1 at 2 months, P < 0.05	No BL information I more visits than C More attrition in C, no comparison dropouts to completers Unclear if assessor blinded Unclear how study population recruited
73	n = 70 F/U immediate 6 months; 42 years	I: Monthly (or more) meetings: diet and PA prescription, feedback, behavior modification C: Usual care, wait listed for I	Decreased total fat intake at immediate F/U, I vs. C, P = 0.047 Deterioration of diet improvements at 6 months	Incomplete BL statistics I more visits than C No mention blinding assessor Volunteer study population; cross-over design Type of DM uncertain (“IDDM”)
74	n = 102; F/U 3, 6 months from BL; 67 years	I: Ten weekly sessions: problem-solving, increased self-efficacy; diet and PA focus C: Wait listed for I	Increased problem-solving for I at 3 and 6 months; between group, P < 0.05	Randomization blocked by medication I more visits than C Volunteer study population
75	n = 66; F/U 4 months; 30–86 years	I: Five × 90-min weekly sessions by nurse: diet and PA, barriers, social and group support C: No information on care received	Improved health practices (diet, PA) I vs. C, P = 0.015	No BL statistics Volunteer study population Number of visits uncertain
76	n = 64; F/U 3, 6 months from BL; 62 years	I: 12 × 1.5-h weekly (didactic) sessions, then 6 × 1.5-h biweekly participatory sessions; based on social action theory C: One didactic class and two mailings	Increased PA 3 months; NSD 6 months	I more visits than C More C dropouts, no comparison dropouts to completers Volunteer study population
77	n = 53; F/U 16 months from BL; 55 years	I-1: 16 weekly sessions of behavioral modification: calorie logs, group PA, monetary incentives I-2: 16 weekly didactic sessions: nutrition and PA C: Four monthly didactic sessions	Improved eating and PA all groups at 4 months, NSD between groups; regression toward BL at 16 m but remained significant	I more visits than C Volunteer study population
78, 97	n = 79; F/U immediate; 68 years	I-1: 10 × 60-min diet education sessions over 4 months; adapted for elderly I-2: I-1 + peer support: group sessions; modeling, reinforcement C: Usual care	Peer support levels correlated with weight loss, glycemic control, P < 0.05	Randomized by site No BL comparisons or attrition information I more visits than C Community recruitment; volunteer study population
83	n = 596; F/U immediate, 6 months; 51 years	I: More nutrition content, follow food pyramid C: Usual education, given meal plan Both I and C: 5 × 2-h weekly group sessions	NSD physical function between choice/no choice groups or between I and C	Randomized into choice/no choice of program, then I and C Attrition 28%, dropouts younger, more male No mention blinding assessor Physician-referred patients or volunteers
93	n = 70; F/U 6 months from BL; 58 years	I: 22 h over 11 weeks, interactive teaching based on cognitive motivational theory C: Didactic teaching, 14 h over 3 days Focus for both I and C: diet and foot care	Increased dietary CHO but NSD between groups Decreased % fat for both groups at 1 month, I > C, P = 0.004	I more contact than C

Continued on following page

Table 3—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
95	n = 20; 12 months from BL; 61 years	I: Group education (diet, PA, BS control) q3 months × 4 C: Usual care	NSD quality of life	I more contact than C Unclear if study population represents target population
106	n = 53; F/U 16 weeks from BL; 55 years	I-1: Nutrition education: 16 weekly sessions; exchange system diet, goal-setting I-2: Nutrition education: four monthly sessions; exchange system diet, goal-setting C: Behavior modification: 16 weekly visits; calorie-counting diet, goal-setting	Decreased caloric intake and % calories from fat in I and C, P < 0.001; NSD between groups	I-2 more visits than C Volunteer study population I-1 and I-2 combined in analysis, as NSD between groups
107	n = 152; F/U 10, 14 weeks from BL; >50 years	I: 10 × 2-h sessions over 14 weeks, culturally sensitive video; nutrition focus C: No intervention	Decreased intake kcal/d C males, P = 0.04 Decreased cholesterol intake C females, P = 0.013	No BL comparisons I more visits than C Attrition 30.2% No information on dropouts No information on blinding assessor Volunteer study population
4. Skills teaching interventions				
90	n = 50; F/U 1 year from BL; 54 years	I: Focused on relationship weight loss and BS control; monetary incentives C: Weight loss program Both groups: 12 weekly meetings, then monthly × 6, F/U in 3 months; behavioral weight control program	Reduction in medications both groups, NSD between groups Decreased caloric intake C, P < 0.004 Decreased depression both groups, NSD between groups	Volunteer study population
5. Coping skills interventions				
86	n = 32; F/U 2 years; 68 years	I-1: Six weekly sessions + 18 monthly support group sessions: coping, discussion, education I-2: Six weekly sessions only; wait list for support group C: Visual care	Increased quality of life Decreased stress I-1 vs. C at 6 months P < 0.05	C is nonrandomized comparison group More visits for I-1 > I-2 > C No information on attrition Unclear if study population represents target population Type of DM unclear

BL, baseline; BS, blood sugar; BP, blood pressure; C, C-1, C-2, control groups; CAI, computer-assisted instruction; CHO, carbohydrate; D/SBP, diastolic/systolic blood pressure; diabetes mellitus; DM2, type 2 diabetes; FBS, fasting blood sugar; F/U, follow-up; HCW, health-care worker; I, I-1, I-2, I-3, intervention groups; IP, inpatient; NSD, no significant difference; OP, outpatient; PA, physical activity; q, every; RN, registered nurse; SD, significant difference; TC, telephone call.

effect on outcomes, and studies with a follow-up period of ≤6 months tended to demonstrate greater effectiveness (31–33,48,50,71,76,84). Few studies had follow-up periods longer than 1 year after the last intervention contact, and these showed mixed effects on glycemic control. The positive studies were either very intensive interventions (79) or had a high attrition rate, leaving a very select group at follow-up (28). Studies with prolonged interventions (follow-up periods >1 year and regular contacts with the intervention subjects during that time) also had mixed results. Two studies (47,65) demonstrated improved glycemic control, although generalizability of these studies is difficult due to a low participation rate (65) and a lack of information on study participation (47). Ten others produced no significant effects, despite regular patient contact (29,34,35,67,69,82,86,88–90).

For knowledge and information in-

terventions, the method of delivery seemed to have a relationship to glycemic control. Compared with didactic interventions, collaborative interventions produced somewhat more favorable results, particularly if interventions were repetitive and ongoing (26,28,48,50,76,84,86).

Most studies focusing on changes in lifestyle generally failed to show improvements in glycemic control compared with control groups (36,39,43,49,66,67,70,72–74,77,78,81–83,88,90–95), but a few studies (31,71,79,84) showed improved glycemic control in researcher-selected or volunteer populations with follow-up <6 months. Improved glycemic control was associated with weight loss in some studies (28,47,48,76,79) and not others (31,65,71,84). Increased physical activity levels were associated with improved glycemic control in one study (65), although another study noted no

changes in physical activity despite improvements in glycemic control (76).

Improved glycemic control and increased knowledge were not consistently correlated. Although a number of studies demonstrated an increase in knowledge with an improvement in glycemic control (26–28,31–33,50), others demonstrated improved metabolic control with no change in knowledge (47,76), and eight studies demonstrated increased knowledge but no significant improvement in glycemic control (29,34–36,40,49,80,88). Two of three studies focusing on coping-skills training produced improvements in glycemic control (85,86); these involved frequent group support meetings.

Computers have been used recently as an educational tool in a number of studies, and effects on glycemic control have been mixed: positive results in three studies (32,39,50) and negative results in another study (67,68). Additionally, vid-

Table 4—Effect of self-management training on glycemic control

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
1. Didactic, knowledge, and information interventions				
33	n = 60; F/U immediate, 4 weeks, ?age	I: Four weekly group sessions; individual sessions as needed C: Started same education 4 weeks later	Decreased HbA _{1c} at 4 weeks I vs. C, P < 0.05	I more visits than C No BL statistics Attrition 29%, dropouts not equal to completers at BL Low participation rate, but NSD participants and nonparticipants
34	n = 345; F/U immediate; 58 years	I: Nine multimedia education classes over 1.5 years C: Usual care	NSD HbA _{1c} or FBS	No mention blinding assessor Low participation rate; nonparticipants older, more male
35	n = 77; F/U 6–18 months from BL; 33 years	I: Five days IP teaching: didactic, individual F/U q3 months, phone access; instruction in self-adjustment insulin C: Five days IP “traditional” education + written information; 3 × 1.5-h sessions; q3 months F/U	Decreased FBS for C and I at 1 month, NSD between groups NSD from BL at 6 months	No BL comparison statistics; no attrition information; No blinding for diet history Low recruitment rate and no information on nonparticipants
47	n = 51; F/U 12 months from BL; 53 years	I: Three weekly didactic, small group sessions q4 months + q2 months visit with doctor C: Visit with doctor q2 months	Decreased HbA _{1c} and FBS in I vs. C, P < 0.05 Exact values not given	I more visits than C No information on participation rates
57	n = 31; F/U 1 week, HbA _{1c} F/U 2 months; 65 years	I: Four weekly TC after hospital discharge: identify deficits and teach C: No TC or other contact	NSD HbA _{1c} between groups	I more contacts than C Unclear if assessor blinded No information on nonparticipants
65, 109	n = 1,139; F/U 5 years; 46 years	I-1: Didactic individual and group sessions q3 months; focus on diet, PA, smoking, BP and BS control I-2: I-1 + clofibrilic acid C: Usual care at DM clinics; q3–4 months	Decreased FBS in I vs. C, P < 0.01	No mention blinding assessor Low participation rate, no information on nonparticipants Clofibrilic acid arm double-blinded
2. Collaborative, knowledge, and information interventions				
26	n = 80; F/U 6 months from BL; 53 years	I: Group sessions: didactic and discussions; no details duration or frequency; F/U q3 months C: Care at general medical clinic q3 months	Decreased FBS in I vs. C at 6 months (9.7 vs. 6.4 mmol/l), P < 0.01	Attrition 25%, no comparison dropouts to completers
27, 28	n = 532; F/U 12–14 months; 57 years	I: Average 2.4 sessions × 1.5-h over 2 months + home visit, TC F/U, contracting, skill exercises, goal-setting; over 26 months C: Usual care	Decreased HbA _{1c} in I (0.43%), P < 0.05, increased in C (0.35%) Decreased FBS I vs. C, P < 0.05	I more visits than C Attrition 51%, differences dropouts and completers No blinding assessor Low participation rate
29	n = 238; F/U 3, 6, 12 months post BL; 56 years	I-1: 13 individual sessions in 12 months I-2: Three-day group interactive course + F/U 3 and 9 months + 2 individual sessions I-3: Six or more individual sessions based on cognitive behavioral theory, TC F/U over 12 months C: 2 × 1-h group education	Decreased HbA _{1c} for all groups at all F/U intervals NSD between groups	BL differences: I-2 better educated; I-1 had longer duration DM I more visits than C Dropouts longer duration DM than completers Unclear if study population represents target population
30	n = 46; F/U immediate, 6 months; 66 years	I: 8 × 2-h small group sessions over 3 months; problem- and participant-focused C: One-day didactic teaching	NSD HbA _{1c} at 6 months	More C excluded due to poor control I more visits than C No mention blinding assessor Nonparticipants older and heavier
32	n = 174; F/U 4–6 months; 57 years	I-1: Computer knowledge assessment program (KAP) + interactive computer teaching (60 min) I-2: KAP (20–40 min) + feedback I-3: KAP only C: No intervention	Decreased HbA _{1c} I-2 (–1.3%, P < 0.05) and I-3 (–0.08%, P < 0.05)	Randomization by year and month birth (no details given) I more contact than C NIDDM results reported here (49% of total study population “IDDM”)
40, 60	n = 558; F/U 6 months; 45 years	I-1: Collaborative education by HCW, 3 h/week × 4 weeks I-2: Same education led by fellow patient C: No intervention I based on Fishbein and Ajzen Health Belief Model	NSD HbA _{1c} at 6 months	Hospitals randomized I more visits than C Uncertain blinding assessor
48	n = 82; F/U 6 months post BL; 56 years	I-1: 11 × 2-h weekly didactic course + 1 individual session I-2: 11-week course + three individual sessions: barriers and support C: Usual care	FBS and HbA _{1c} decreased for I-1 and I-2 at 3 and 6 months, P < 0.05	No BL statistics comparing groups I more visits than C Attrition 40%, no comparison dropouts to completers Volunteer study population

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Table 4—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
50	n = 40; F/U 3 months; 57 years	I: CAI, 4 × 1-h session: didactic, some feedback and testing C: Didactic group teaching; 4 × 3-h	Decreased GHb I (relative change 11%), P < 0.05, increased C (14%), P < 0.05, between group difference, P = 0.001	No BL group comparison statistics Low participation rate, no information on nonparticipants or dropouts
54	n = 1.07; F/U 1, 4 months; 60 years	I: 2 × 2-h group didactic + practice + feedback + usual care C: Usual care: individual education based on perceived patient need Both in IP setting	NSD BS at 4 months	Randomized by hospital number No blinding assessor No information on participation rates
55	n = 41; F/U 2 months; 60 years	I-1: Three-day program + group session with pharmacist I-2: Three-day program + individual session with pharmacist; TC F/U C: Standard center 3-day education program	NSD % change in BS between I and C	No BL comparisons I more contact than C 23% had unusable data for SMBG
59	n = 60; F/U 3 months from BL; 55 years	I: Three-day group education, with F/U of 4 TC and 1 home visit; reinforce knowledge and skills C: Three-day group education	NSD HbA _{1c} between groups	I more contact than C Unclear if study population represents target population
87	n = 247; F/U 12 months from BL; 54 years	I: 12 weekly sessions over 3 months; Spanish videos, followed by 14 group support sessions in 9 months, by lay HCW C: Wait listed for the intervention	Decreased GHb 1.7% in I, increased 0.3% in C Decreased FBS 18.9 mg/dl in I, increased 3.9 in C	No BL comparison I more contact than C No information on attrition No mention blinding assessor No statistics
96	n = 156; F/U ? immediate; 58 years	I-1: Patient selects behavior for improvement I-2: Behavioral strategies to increase compliance I-3: Behavioral strategies + instruction on behavioral analysis C: Routine care with consistent F/U by RN: I-1,2,3 based on social cognitive theory I over 13 months	NSD GHb I and C	No information on attrition Volunteer study population Number of patient contacts unclear F/U interval unclear
98	n = 22; F/U 32 weeks from baseline; 61 years	I: Weekly to biweekly home visits: nutrition, exercise, foot care, SMBG; by nursing students C: Usual care	NSD GHb or BS at 32 weeks	Attrition 24%, no comparison dropouts to completers No mention blinding assessor Unclear if study population represents target population
99	n = 56; F/U 6 months; 64 years	I: Monthly ×6 group sessions: behavior modification (contracts, feedback), general knowledge C: Usual care	Decreased GHb immediate F/U I and C (P < 0.05), NSD between groups; NSD at 6 months Decreased FBS I at immediate F/U, NSD between groups	I more contact than C Attrition 32%, no comparison dropouts to completers Participation rate 37%, no comparison participants to nonparticipants
3. Lifestyle interventions				
31	n = 40; F/U 6 months from BL; 35 years	I-1: Lunch demonstrations I-2: Videotape education C: Dietitian instruction and written information Three visits total for all groups over 6 months	Decreased HbA _{1c} I-1 (-2.4%, P < 0.025) and I-2 (-3.3%, P < 0.001) Decreased HbA _{1c} correlated with decreased CHO variation, P < 0.02	No mention blinding assessor Study population selected by researchers; low participation rate Type of diabetes unclear ("insulin dependent")
36	n = 87; F/U 12 months from BL; 56 years	I: Five group sessions over 6 months, focus on weight loss C: Individual education on weight loss by dietitian; 3 or more visits in 12 months	Decreased HbA _{1c} I at 6 months, P < 0.001; NSD I vs. C at 1 year	
39	n = 105; F/U immediate, 12 months; 45 years	I: Interactive computer program on diet; 90 min/month over 6 months C: Wait listed for I Both groups received 5 days of teaching	NSD HbA _{1c} or fructosamine at immediate F/U Decreased HbA _{1c} at 18 months (10.8 to 9.6, P < 0.001)	I more contact than C Attrition appears to be 76% at 12 months F/U; no comparison dropouts to completers No mention blinding assessor Crossover design No information on patient recruitment
43	n = 201; F/U 6 months; 53 years	I: Culturally appropriate flashcards: diet, SMBG; delivered by lay HCW C: Usual care	Decreased HbA _{1c} in I (-0.34%, P > 0.05)	I more contact than C Intensity of intervention unclear

Continued on following page

Table 4—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
49	n = 41, F/U 6 months; 61 years	I: Psychologist-led group sessions on PA and diet C: Didactic lectures on diet and DM Both groups 10 × 1-h sessions over 6 months	Decreased HbA _{1c} for I and C, NSD between groups Decreased mean BS at 6 months for I, between group difference, <i>P</i> < 0.05	Dropouts (22%) had higher mean BS; equal number dropouts I and C Low participation rate, no information on nonparticipants
66	n = 148; F/U 6 months from BL; 55 years	I: Advice to decrease fat to <30% total calorie intake C: Advice to decrease CHO to <40% total calorie intake Both I and C received individual counseling by dietitian; three home visits	NSD HbA _{1c} between groups NSD fasting plasma glucose between groups	
67, 68, 104	n = 206; F/U 12 months from BL; 62 years	I: Single visit: focus on diet; goal-setting, interactive video on barriers, F/U q3 months C: Usual care q3 months	NSD HbA _{1c} at 12 months	Unclear if food record reviewers were blinded Low participation rate; participants differ from nonparticipants
69, 82, 89, 103	n = 86; F/U 15, 27 months from BL; 53 years	I: Six individual visits at 2-month intervals; intensive therapy for weight, BS control, diet, PA; then q3 months visits C: Usual care q2–3 months Both groups 3 visits/3 months basic education before randomization	Decreased FBS for I > C at 15 months, <i>P</i> = 0.02; NSD 27 months NSD HbA _{1c} 15 and 27 months	I more visits than C No mention blinding assessor No information on nonparticipants I more contact than C
70	n = 75; F/U 12 months from BL; 61 years	I: Educational videos, personal and family support q2 weeks for 6 months + 3 h counseling by dietitian C: Review session × 3	NSD GHb	
71	n = 60; F/U 12 weeks from BL; 55 years	I: Individualized advice on low glycemic index foods C: Standard, individualized diet advice	Decreased FBS I and C, significant only for I, <i>P</i> < 0.05 Decreased fructosamine I vs. C, <i>P</i> < 0.05	No mention blinding assessor Unclear how much intervention time
72	n = 78; F/U 2 months; 42–75 years	I-1: 5 × 2-h weekly education: calories, fat, fiber I-2: I-1 + goal setting, problem-solving, feedback C: Wait listed for I	NSD GHb	No BL information I more visits than C More attrition in C, no comparison dropouts to completers Unclear if assessor blinded Unclear how study population recruited
73	n = 70; F/U immediate, 6 months; 42 years	I: Monthly (or more) meetings: diet and PA prescription, feedback, behavior modification C: Usual care; wait listed for I	NSD HbA _{1c} immediate or 6 months	Incomplete BL statistics I more visits than C No mention blinding assessor Volunteer study population Crossover design Type of DM uncertain (“IDDM”)
74	n = 102; F/U 3, 6 months from BL; 67 years	I: 10 weekly sessions: problem-solving, increased self efficacy, diet and PA focus C: Wait listed for I	Decreased HbA _{1c} in I and C at 3 months (0.5%), NSD between groups, return to BL at 6 months	Randomization blocked by medication I more visits than C Volunteer study population
76	n = 64; F/U 3, 6 months from BL; 62 years	I: 12 × 1.5-h weekly (didactic), sessions then 6 × 1.5-h biweekly participatory diet and exercise sessions, based on social action theory C: One didactic class and two mailings	Decreased HbA _{1c} at 3 months (−1.5%) and 6 months (−1.1%), <i>P</i> < 0.01	I more visits than C More C dropouts, no comparison dropouts to completers Volunteer study population
77	n = 53; F/U 16 weeks, 16 months from BL; 55 years	I-1: 16 weekly sessions: behavioral modification, calorie logs, group PA, monetary incentives I-2: 16 weekly didactic sessions nutrition and PA C: Four monthly didactic sessions	Decreased FBS and HbA _{1c} all groups at 16 weeks, <i>P</i> < 0.01, NSD between groups NSD FBS and HbA _{1c} at 16 months	I more visits than C Volunteer study population
78, 97	n = 79; F/U immediate; 68 years	I-1: 10 × 60-min diet education sessions over 4 months; adapted for elderly I-2: I-1 + peer support: group sessions, modeling, reinforcement C: Usual care	Decreased HbA _{1c} at 8 weeks, for I-2, <i>P</i> < 0.05, not maintained at 16 weeks	Randomized by site No BL comparisons or attrition information I more visits than C Community recruitment; volunteer study population

Continued on following page

Table 4—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
79, 100, 101	n = 76; F/U 3, 6, 18 months from BL; 54 years	I-1: Diet focus; goal-setting, modify environment I-2: PA focus with participation I-3: Diet + PA C: Didactic teaching All groups: 10 × 2-h weekly sessions: I based on behavior and cognitive modification strategies	Decreased BS I-1 vs. C at 6 months, P < 0.037; NSD HbA _{1c} Decreased HbA _{1c} 1-3 vs. C at 18 months (difference 1.8%, P < 0.05)	Randomized by group meeting attended Volunteer study population
80	n = 40; F/U 2, 5 months from BL; 59 years	I: 3 × 1.5-h individual learning activity packages with diet information, goals, activities C: 3 × 1.5-h didactic lectures	Decreased HbA _{1c} in C (4.5%) at 5 months, P < 0.05; NSD I group	Attrition 23%, no comparison dropouts to completers Volunteer study population from DM education program
81, 102	n = 247; F/U 6 months from BL; 57 years	I: Three or more individual visits with dietitian, over 6 weeks, following practice guidelines C-1: One visit producing nutrition care plan C-2: Nonrandomized comparison group; no intervention	Decreased FBS and HbA _{1c} I at 6 months, P < 0.001; decreased C-1, P < 0.01; NSD between I and C-1	Nonrandomized C-2 C less time with dietitian Attrition 28% for lab studies, unclear if dropouts equal completers at BL Volunteer study population or physician-referred
83	n = 596; F/U immediate, 6 months; 51 years	I: More nutrition content, follow food pyramid C: Usual education, given meal plan Both I and C: 5 × 2-h weekly group sessions	Decreased HbA _{1c} in C (0.9%, P = 0.035) Patient choice had no effect	Randomized into choice/no choice of program, then I and C Attrition 28%, dropouts younger, more male No mention blinding assessor Physician-referred patients or volunteers
84	n = 163; F/U immediate, 6 months; 64 years	I: Six monthly sessions on diet C: Usual care; wait listed	Decreased postprandial BS at 6 months in I vs. C, P = 0.009	No BL statistics I more visits than C Attrition 47%, but dropouts equal completers at BL No information on patient recruitment Type of DM unclear
88	n = 80; F/U 12 months from BL; 56 years	I: Six individual sessions on diet, by nurse C: Physician gave handout at initial visit on weight loss Both groups 6 visits/12 months	Decreased FBS all groups, P < 0.01, NSD between groups Decreased HbA _{1c} C females and I males, P < 0.001, NSD between groups	No BL statistics
90	n = 50; F/U 1 year from BL; 54 years	I: Focused on relationship weight loss and BS control; monetary incentives C: Weight loss program Both groups: 12 weekly meetings, then monthly ×6, F/U in 3 months; behavioral weight control program	NSD HbA _{1c} at 1 year for I or C	Volunteer study population
91	n = 120; F/U 7, 11 months from BL; 54 years	I-1: Six monthly small-group meetings, diet and PA information; audio-visual materials culturally sensitive I-2: 1-h didactic + five monthly discussions on BS control C: 1-h didactic only	NSD HbA _{1c} between or within groups at 7 or 11 months	I more visits than C Attrition 32% at 11 months, NSD dropouts to completers
92	n = 40; F/U immediate, 6 weeks; 54 years	I: Behavioral group: 6 × 1.5-h weekly meetings; cues for eating, daily record C: Individual diet counseling, total 1.25 h	Decreased BS immediate F/U for I, P < 0.05, NSD 6 weeks NSD between groups for BS	I more visits than C Unclear how patients selected
93	n = 70; F/U 6 months from BL; 58 years	I: 22 h over 11 weeks, interactive teaching based on cognitive motivational theory C: Didactic teaching, 14 h over 3 days Focus for both I and C: diet and foot care	NSD FBS either group Decreased fructosamine both groups at 1 month, P < 0.0001, return to BL at 6 months	I more contact than C

Continued on following page

Table 4—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
94	n = 23; F/U 6 months from BL; 33–70 years	I: Self-management skills (stimulus control, monitoring, reinforcement); 5 diet classes/day for 5 days C: Conventional teaching 1 h/day × 5; Both groups: 5-days IP admission; F/U q2 weeks for 2 months, then 3 and 6 months	FBS decreased both groups, NSD between groups at 6 months	Randomized by week of admission No BL statistics No mention blinding assessor Patients selected by physicians
95	n = 120; 12 months from BL; 61 years	I: Group education (diet, PA, BS control) q3 months × 4 C: Usual care	NSD HbA _{1c} , FBS	I more contact than C Unclear if study population represents target population
4. Skills teaching interventions				
61	n = 20; F/U 1 year from end 16-week I; 53 years	I: Information on how to use BS measures by adjusting diet and PA C: Self-monitoring of BS; no feedback Both groups: 13 sessions over 16 weeks, then 9 in 6 months; didactic and participatory; focus on weight control	Decreased HbA _{1c} both I and C at immediate F/U, $P < 0.0001$, NSD between groups, NSD from BL at 1 year	No mention blinding assessor Volunteer study population
63	n = 50; F/U 6 months; adult	I: Additional participatory teaching on foot care during OP education C: Usual education, with routine, didactic foot education Both groups: 5 days OP DM education	Decreased HbA _{1c} I, $P = 0.002$ and C, $P = 0.051$ No values or between group statistics	Randomized by week entering program; no BL comparisons Attrition 35% I, 44% C, no comparison dropouts to completers No mention blinding assessor No demographic data; type of DM unclear
5. Coping skills interventions				
85	n = 64; F/U 6 weeks; 50 years	I: 6 × 2-h weekly group sessions: patient empowerment, goal-setting, problem-solving, stress management C: Wait listed	Decreased HbA _{1c} I > C $P = 0.05$, I decreased 0.73%	No BL comparisons; 18 patients not randomly assigned I more contact than C Volunteer study population 64% DM2 HbA _{1c} measured immediately after program for C, 6 weeks after for I
86	n = 32; F/U 2 years from BL; 68 years	I-1: Six weekly sessions + 18 monthly support group sessions: coping, discussion, education I-2: Six-weekly sessions only; wait list for support group C: Usual care	Decreased HbA _{1c} I-1 and I-2 vs. C at 2 years, $P < 0.05$; NSD between I-1 and I-2	C is nonrandomized comparison group More visits for I-1 > I-2 > C No information on attrition Unclear if study population represents target population Type of DM unclear
105	n = 55; F/U 3, 6, 12, 18 months from BL; 53 years	I-1: Behavior modification: focus on self-control procedures; records of diet and exercise I-2: Cognitive modification: focus on cognitions; self-statements; goal-setting I-3: Cognitive-behavior modification: combined I-1 and I-2 C: Relaxation training to cope with stress All groups got nine weekly sessions of 1.5 h	NSD HbA _{1c}	

BL, baseline; BS, blood sugar; BP, blood pressure; C, C-1, C-2, control groups; CAI, computer-assisted instruction; CHO, carbohydrate; D/SBP, diastolic/systolic blood pressure; DM, diabetes mellitus; DM2, type 2 diabetes; FBS, fasting blood sugar; F/U, follow-up; HCW, health-care worker; I, I-1, I-2, I-3, intervention groups; IP, inpatient; NSD, no significant difference; OP, outpatient; PA, physical activity; q, every; RN, registered nurse; SD, significant difference; TC, telephone call.

eatapes have been used as adjuncts for teaching, with positive (31) and negative (91) results.

Cardiovascular disease risk factors

A large number of studies examined the effects of diabetes self-management training on risk factors for cardiovascular disease, including body weight, serum lipid

levels, and blood pressure (Table 5). Thirteen studies demonstrated positive effects on weight loss; the average weight loss for these studies was ~2 kg (range 1.3–3.1) (28,36,38,47,66,72,74,76,80,82,84,89). Most studies with positive results involved regular contacts or reinforcement sessions (38,47,66,76,82,84) or very short follow-up periods (72,74), al-

though four studies had follow-up periods of ≥5 months (36,38,80,82). All other studies with follow-up of ≥6 months after the end of the intervention failed to show significant differences in weight loss between control and intervention groups (30,31,61,65,71,73,77,79,84,87,88,90,91). A number of other studies with shorter follow-up periods also had

Table 5—Effect of self-management training on cardiovascular disease risk factors and cardiovascular disease

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
1. Didactic, knowledge, and information interventions				
34	n = 345; F/U immediate; 58 years	I: Nine multimedia education classes over 1.5 years C: Usual care	NSD BP, weight, lipids	No mention blinding assessor Low participation rate; nonparticipants older, more male
47	n = 51; F/U 12 months from BL; 53 years	I: Three weekly didactic, small group sessions q4 months + q2 months visit with doctor C: Visit with doctor q2 months	Decreased weight 2 kg in I vs. C, $P < 0.05$ NSD cholesterol, triglycerides between groups	I more visits than C No information on participation rates
65, 109	n = 1,139; F/U 5 years; 46 years	I-1: Didactic individual and group sessions q3 months; focus on diet, PA, smoking, BP and BS control I-2: I-1 + clofibrilic acid C: Usual care at DM clinics; q3–4 months	NSD myocardial infarctions, ischemic heart disease, mortality; NSD BMI Increased cholesterol in all groups, NSD between groups	No mention blinding assessor Low participation rate, no information on nonparticipants Clofibrilic acid arm double-blinded
2. Collaborative, knowledge, and information interventions				
27, 28	n = 532; F/U 12–14; 57 years	I: Average 2.4 sessions × 1.5 h over 2 months + home visit, TC F/U, contracting, skill exercises, goal-setting; over 26 months C: Usual care	Decreased SBP, DBP, between group difference, $P < 0.05$ Decreased weight 1, between group difference 2.8 lb, $P < 0.05$	I more contact than C Attrition 51%, differences dropouts and completers No blinding assessor Low participation rate
29	n = 238; F/U 3, 6, 12 months from BL; 56 years	I-1: 13 individual sessions in 12 months I-2: Three-day group interactive course + F/U 3 and 9 months + two individual sessions I-3: Six or more individual sessions based on cognitive behavior theory, TC F/U over 12 months C: 2 × 1-h group education	NSD SBP, total cholesterol and BMI Decreased DBP I-3 vs. C at 12 months, $P < 0.01$	BL differences: I-2 better educated; I-1 longer duration DM I more visits than C Dropouts longer duration DM than completers Unclear if study population represents target population
30	n = 46; F/U immediate, 6 months; 66 years	I: 8 × 2-h small group sessions over 3 months; problem- and participant-focused C: One-day didactic teaching	NSD serum lipids or weight at 6 months	I more visits than C More C excluded due to poor control No mention blinding assessor Nonparticipants older and heavier
48	n = 82; F/U 6 months from BL; 56 years	I-1: 11 × 2-h weekly didactic course + one individual session I-2: 11-week course + three individual sessions: barriers and support C: Usual care	Decreased cholesterol all three groups at 3 months, maintained at 6 months Decreased weight at 3 months all three groups, $P < 0.01$, maintained at 6 months NSD between groups; average loss 10 lb at 6 months	No BL statistics comparing groups I more visits than C Attrition 40%, no comparison dropouts to completers Volunteer study population
59	n = 60; F/U 3 months from BL; 55 years	I: Three-day group education, with F/U of four TC and one home visit; reinforce knowledge and skills C: Three-day group education	NSD weight between groups	I more contact than C Unclear if study population represents target population
87	n = 247; F/U 12 months from BL; 54 years	I: 12 weekly sessions over 3 months: Spanish videos, followed by 14 group support sessions in 9 m; by lay HCW C: Wait listed for the intervention	Decreased weight at 6 months (4 lb in I); back to BL at 12 months	No BL comparison I more contact than C No information on attrition No mention blinding assessor; no statistics
96	n = 156; F/U ? immediate; 58 years	I-1: Patient selects behavior for improvement; I-2: Behavioral strategies to increase compliance I-3: Behavioral strategies + instruction on behavioral analysis C: Routine care with consistent F/U by RN I-1,2,3 based on social cognitive theory; I over 13 months	NSD weight between I and C	No information on attrition Volunteer study population; F/U interval unclear Number of patient contacts unclear
98	n = 22; F/U 32 weeks from BL; 61 years	I: Weekly to biweekly home visits; nutrition, exercise, foot care, SMBG; by nursing students C: Usual care	NSD weight between groups	Attrition 24%, no comparison dropouts to completers No mention blinding assessor Unclear if study population represents target population

Continued on following page

Table 5—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
99	n = 56; F/U 6 months; 64 years	I: Monthly ×6 group sessions: behavior modification (contracts, feedback), general knowledge C: Usual care	Decreased LDL, total cholesterol at immediate F/U, $P < 0.05$; NSD 6 months Decreased weight at 6-month I (-8 lb), $P = 0.02$; NSD between groups	I more contact than C Attrition 32%, no comparison dropouts to completers Participation rate 37%, no comparison participants to nonparticipants
3. Lifestyle interventions				
31	n = 40; F/U 6 months from BL; 35 years	I-1: Lunch demonstrations I-2: Videotape education C: Dietitian instruction and written information Three visits total for all groups over 6 months	NSD BMI	No mention blinding assessor Study population selected by researchers; low participation rate Type of diabetes unclear ("insulin dependent")
36	n = 87; F/U 12 months from BL; 56 years	I: Five group sessions over 6 months, focus on weight loss C: Individual education on weight loss by dietitian; 3 or more visits in 12 months	Decreased weight I (5.5 kg) and C (3 kg) at 1 year, between group difference, $P < 0.05$	
38	n = 32; F/U immediate, 1 year; 53 years	I: Two sessions: dietitian and CAI C: 2 × 30-min sessions: dietitian only Teaching for both over approximately 1 month	Decreased weight I (4.6 lb, $P < 0.005$), maintained at 1 year, NSD C	No BL statistics Unclear if blinding assessor Type of DM uncertain
39	n = 105; F/U immediate, 12 months; 45 years	I: Interactive computer program on diet, 90 min/month over 6 months C: Wait listed for 1 Both groups received 5 days teaching	NSD weight	I more contact than C Attrition appears to be 76% at 12 months F/U, no comparison dropouts to completers No mention blinding assessor No information on patient recruitment Crossover design
49	n = 41; F/U 6 months; 61 years	I: Psychologist-led group sessions on PA and diet C: Didactic lectures on diet and DM Both groups 10 × 1-h sessions over 6 months	NSD % overweight	Dropouts (22%) higher mean BS; equal number dropouts I and C Low participation rate, no information on nonparticipants
66	n = 148; F/U 6 months from BL; 55 years	I: Advice to decrease fat <30% total calorie intake C: Advice to decrease CHO to <40% total calorie intake Both I and C received individual counseling by dietitian, three home visits	Obese patients decreased weight I > C, $P < 0.05$ Decreased cholesterol in both groups I > C, $P < 0.001$ NSD HDL or triglycerides	
67, 68, 104	n = 206; F/U 12 months from BL; 62 years	I: Single visit: focus on diet, goal-setting, interactive video on barriers; F/U q3 months C: Usual care q3 months	Decreased cholesterol for I vs. C at 12 months, $P = 0.002$ NSD BMI	Unclear if food record reviewers were blinded Low participation rate; participants differ from nonparticipants
69, 82, 89, 103	n = 86; F/U 15, 27 months from BL; 53 years	I: Six individual visits at 2-month intervals: intensive therapy for weight, BS control, diet, PA; then q3 months visits C: Usual care q2-3 months Both groups 3 visits/3 months basic education before randomization	Increased HDL I at 15 months, $P < 0.001$, NSD 27 months Weight loss I (3.1 kg) > C at 15 months, $P = 0.022$; NSD from BL at 27 months NSD BP 15 months	I more visits than C No mention blinding assessor No information on nonparticipants
70	n = 75; F/U 12 months from BL; 61 years	I: Educational videos, personal and family support q2 weeks for 6 months + 3 h counseling by dietitian C: Review session × 3	NSD weight, BP, cholesterol	I more contact than C
71	n = 60; F/U 12 weeks from BL; 55 years	I: Individualized advice on low glycemic index foods C: Standard, individualized diet advice	NSD weight either group Decreased cholesterol I vs. C, $P < 0.05$	No mention blinding assessor Unclear how much intervention time
72	n = 78; F/U 2 months; 42-75 years	I-1: 5 × 2-h weekly education: calories, fat, fiber I-2: I-1+ goal setting, problem-solving, feedback C: Wait listed for 1	Decreased weight for I-2 at 2 months, $P < 0.05$	No BL information I more visits than C More attrition in C, no comparison dropouts to completers Unclear if assessor blinded Unclear how study population recruited

Continued on following page

Table 5—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
73	n = 70; F/U, immediate, 6 months; 42 years	I: Monthly (or more) meetings: diet and PA prescription, feedback, behavior modification C: Usual care; wait listed for I	NSD weight F/U immediate or 6 months NSD BP Increased Vo _{2max} at 6 months	Incomplete BL statistics I more visits than C No mention blinding assessor Volunteer study population Cross-over design Type of DM uncertain (“IDDM”)
74	n = 102; F/U 3, 6 months from BL; 67 years	I: 10 weekly sessions: problem-solving, increased self efficacy, diet, and PA focus C: Wait listed for I	Decreased weight for I at 3 months (6 lb), maintained at 6 months (4.5 lb, P < 0.002)	Randomization blocked by medication I more visits than C Volunteer study population
75	n = 66; F/U 4 months; 30–86 years	I: 5 × 90-min weekly sessions by nurse: diet, PA, barriers, social and group support C: No information on care received	NSD BMI	No BL statistics Volunteer study population Number of visits uncertain
76	n = 64; F/U 3, 6 months from BL; 62 years	I: 12 × 1.5-h weekly didactic sessions, then 6 × 1-h biweekly participatory sessions; based on social action theory C: One didactic class and two mailings	Decreased weight I at 3 and 6 months (–1.3 kg), P < 0.01 NSD SBP; decreased DBP 6 months, P < 0.05 NSD lipids	I more visits than C More C dropouts, no comparison dropouts to completers Volunteer study population
77	n = 53; F/U 16 weeks, 16 months from BL; 55 years	I-1: 16 weekly sessions: behavioral modification, calorie logs, group PA, monetary incentives I-2: 16 weekly didactic sessions: nutrition and PA C: Four monthly didactic sessions	Decreased weight I-1 at 16 weeks (–6.3 kg), between group, P < 0.01 Decreased weight all groups at 16 months, average change –2.8 kg, NSD between groups	I more visits than C Volunteer study population
78, 97	n = 79; F/U immediate; 68 years	I-1: 10 × 60-min diet education sessions over 4 months; adapted for elderly I-2: I-1 + peer support: group sessions, modeling, reinforcement C: Usual care	Decreased weight I-2 at 8 weeks (5.5 lb, P < 0.05), NS gain to 16 weeks, NSD between groups	Randomized by site; no BL comparisons or attrition information I more visits than C Community recruitment; volunteer study population
79, 100, 101	n = 76; F/U 3, 6, 18 months from BL; 54 years	I-1: Diet focus: goal-setting, modify environment I-2: PA focus with participation I-3: Diet + PA C: Didactic teaching All groups: 10 × 2-h weekly sessions; I based on behavior and cognitive modification strategies	Decreased weight I-1 at 3 months (between group difference 3.9 kg, P < 0.03), and 6 months (4.5 kg, P < 0.02); NSD from BL at 18 months Decreased LDL I-1, P < 0.05 and I-3, P < 0.01 vs. C at 6 months Increased HDL I-1 vs. other groups, P < 0.05 at 3 months; NSD 6 months	Randomized by group meeting attended Volunteer study population
80	n = 40; F/U 2, 5 months from BL; 59 years	I: 3 × 1.5-h individual learning activity packages with diet information, goals, activities C: 3 × 1.5-h didactic lectures	Decreased % ideal body weight for I at 5 months, P < 0.05	Attrition 23%; no comparison dropouts to completers Volunteer study population from DM education program
81, 102	n = 247; F/U 6 months from BL; 57 years	I: Three or more individual visits with dietitian, over 6 weeks, following practice guidelines C-1: One visit producing nutrition care plan C-2: Nonrandomized comparison group; no intervention	Decreased total cholesterol I at 6 months, P < 0.05; NSD C NSD HDL or LDL I or C Decreased weight I and C, P < 0.01	Nonrandomized C-2 C less time with dietitian Attrition 28% for lab studies, unclear if dropouts equal completers at BL Volunteer study population or physician-referred
83	n = 596; F/U immediate, 6 months; 51 years	I: More nutrition content, follow food pyramid C: Usual education, given meal plan Both I and C: 5 × 2-h weekly group sessions	NSD BMI between group with choice and no choice Decreased cholesterol in I, between group difference, P = 0.04	Randomized into choice/no choice of program, then I and C Attrition 28%, dropouts younger, more male No mention blinding assessor Physician-referred patients or volunteers
84	n = 163; F/U immediate, 6 months; 64 years	I: Six monthly sessions on diet C: Usual care; wait listed	Decreased weight females at immediate F/U, P = 0.0061 (amount of loss uncertain)	No BL statistics I more visits than C Attrition 47%, but dropouts equivalent to completers at BL No information on patient recruitment Type of DM unclear

Continued on following page

Table 5—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
88	n = 80; F/U 12 months from BL; 56 years	I: Six individual sessions on diet, by nurse C: Physician gave handout at initial visit on weight loss Both I and C 6 visits/12 months	Decreased weight both groups, NSD between groups NSD lipids or BP	No BL statistics
91	n = 120; F/U 7, 11 months from BL; 54 years	I-1: Six monthly small-group meetings, diet and PA; audiovisual materials culturally sensitive I-2: 1-h didactic + five monthly discussions on BS control C: 1-h didactic only	Decreased weight I-1 at 7 months, (1 kg) $P < 0.05$, not sustained at 11 months NSD triglycerides or cholesterol	I more visits than C Attrition 32% at 11 months, NSD dropouts to completers
92	n = 40; F/U immediate, 6 weeks; 54 years	I: Behavioral group: 6 × 1.5-h weekly meetings; cues for eating, daily record C: Individual diet counseling, total 1.25 h	Decreased weight C > I at 6 weeks, $P < 0.01$ Decreased triglycerides C at 12 weeks, $P < 0.05$ NSD LDL and HDL	I more visits than C Unclear how patients selected
93	n = 70; F/U 6 months from BL; 58 years	I: 22 h over 11 weeks, interactive teaching based on cognitive motivational theory C: Didactic teaching, 14 h over 3 days Focus for both I and C: diet and foot care	Decreased BMI both groups; NSD between groups Decreased cholesterol I at 6 months, between group, $P = 0.003$	I more contact than C
94	n = 23; F/U 6 months from BL; 33–70 years	I: Self-management skills (stimulus control, monitoring, reinforcement); five classes/day for 5 days; diet focus C: Conventional teaching 1 h/day × 5 Both groups: 5-days IP admission F/U q2 weeks for 2 months, then 3 and 6 months	Decreased % overweight I vs. C at 6 months, $P < 0.01$	Randomized by week of admission No BL statistics No mention blinding assessor Patients selected by physicians
95	n = 120; 12 months from BL; 61 years	I: Group education (diet, PA, BS control) q3 months × 4 C: Usual care	Decreased weight, BMI I and C; NSD between groups	I more contact than C Unclear if study population represents target population
107	n = 152; F/U 10, 14 weeks from BL; 61 years	I: 10 × 2-h sessions over 14 weeks, culturally sensitive video; nutrition focus C: No intervention	Decreased weight I and C males at 14 weeks (2 kg)	No BL comparisons I more visits than C Attrition 30.2%, no information on dropouts No information on blinding assessor Volunteer study population
4. Skills teaching interventions				
61	n = 20; F/U 1 year from end 16-week I; 53 years	I: Information on how to use BS measures by adjusting diet and PA C: Self-monitoring of BS; no feedback Both groups: 13 sessions over 16 weeks, then 9 in 6 months; didactic and participatory; focus on weight control	Decreased weight both I and C (6.0 kg end course, 3.7 kg at 1 y); NSD between groups	No mention blinding assessor Volunteer study population
64	n = 203; F/U 13 months I, 9 months C; ?age	I: 1-h didactic group education on foot care C: No education	NSD mortality	Randomized on SSN No information on dropouts No mention blinding assessor No information on nonparticipants Type of DM unclear Volunteer study population
90	n = 50; F/U 1 year from BL; 54 years	I: Focused on relationship weight loss and BS control; monetary incentives C: Weight loss program Both groups: 12 weekly meetings, then monthly ×6, F/U in 3 months; behavioral weight control program	Decreased weight I and C at 1 year (6.1 kg), NSD between groups Decreased SBP both I and C at 1 year; NSD between groups NSD cholesterol and HDL; decreased triglycerides both I and C	Volunteer study population

Continued on following page

Table 5—Continued

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Comments
5. Coping skills and interventions				
105	n = 55; F/U 3, 6, 12, 18 months from BL; 53 years	I-1: Behavior modification: focus on self-control procedures; records of diet and exercise I-2: Cognitive modification: focus on cognitions: self-statements; goal setting I-3: Cognitive-behavior modification: combined I-1 and I-2 C: Relaxation training to cope with stress All groups got nine weekly sessions of 1.5 h	Decreased weight (8 lb in men, 0.1 in women) at 18 months, I-1 > I-2,3 and C	

BL, baseline; BS, blood sugar; BP, blood pressure; C, C-1, C-2, control groups; CAI, computer-assisted instruction; CHO, carbohydrate; D/SBP, diastolic/systolic blood pressure; DM, diabetes mellitus; DM2, type 2 diabetes; FBS, fasting blood sugar; F/U, follow-up; HCW, health-care worker; I, I-1, I-2, I-3, intervention groups; IP, inpatient; NSD, no significant difference; OP, outpatient; PA, physical activity; q, every; RN, registered nurse; SD, significant difference; TC, telephone call.

negative results (29,34,39,59,75,78,82, 92,96–99). Only three studies involved didactic interventions (34,47,65), and only one of these studies showed a decrease in weight (47).

A large number of studies examined the effects of self-management training on lipid levels, and some produced improvement in total cholesterol (range -0.9 to -0.07 mmol/dl) (66,68,81,83,93), LDL (-0.4 mmol/dl) (100), and HDL (+0.1 mmol/dl) (100). Others found initial positive results but no significant difference from baseline at final follow-up (69,82,101). Positive studies involved interactive, generally individualized, repetitive interventions. Some studies have shown no beneficial effects on lipids (29,34,47,65,76,88,91,92). Of the three didactic studies (34,47,65), none resulted in improved lipid profiles.

Studies examining blood pressure control also revealed mixed results. Some studies demonstrated a decrease in systolic blood pressure (-4 mmHg) (28) and diastolic blood pressure (-3 to -8 mmHg) (27–29,76), whereas others showed no significant changes (34,73,82, 89).

Only two studies examined cardiovascular disease events or mortality, one of which found no significant difference in cardiovascular disease or mortality events after 5 years of visits every 3 months (65); the other study found no significant difference in mortality 13 months after a 1-h group didactic educational session (64).

Economic and health-care utilization outcomes

Most studies examining economic outcomes and health-care utilization (Table 6) failed to demonstrate improvements in measured parameters (34,46,60), except the study by Wood (54), which demonstrated a decrease in emergency room visits 4 months after a short-duration intervention. Glasgow et al. (68) calculated that the cost of a social cognitive theory-based lifestyle intervention, effective in decreasing cholesterol and in improving food habits, was \$137 per patient. Franz et al. (102) found the per-patient cost-per-unit change in glycohemoglobin to be lower for control subjects than for intervention patients. They also demonstrated (102) a cost-effectiveness ratio (direct costs only) of \$56.26 per percent change in HgA_{1c} for results achieved at 6-month follow-up. No cost-benefit analyses of diabetes education were identified.

CONCLUSIONS — A large number of randomized controlled trials of the effectiveness of self-management training in individuals with type 2 diabetes have been performed. Despite limitations in methodology and heterogeneous population characteristics, settings, interventions, outcomes, and lengths of follow-up, a number of generalizations can be made from these studies (Table 7).

Effectiveness of interventions

In reviewing the literature, it is clear that diabetes self-management training has

evolved from the primarily didactic interventions of the 1970s and 1980s into the collaborative, more theoretically based “empowerment” models of the 1990s (12). Didactic interventions focusing on the acquisition of knowledge and information demonstrate positive effects on knowledge but mixed results on glycemic control and blood pressure and no effect on weight. Collaborative interventions focusing on knowledge tend to demonstrate positive effects on glycemic control in the short term and mixed results with follow-up >1 year. Effects of collaborative interventions on lipids, weight, and blood pressure were mixed.

It is apparent that factors other than knowledge are needed to achieve long-term behavioral change and that this may account for the lack of a consistent positive relationship between knowledge and glycemic control. It has been suggested that 1) although intensive treatment can improve metabolic control, the role of patient education in that process is uncertain (34); 2) changes in attitude and motivation are needed to achieve metabolic control (35); 3) integrating education with other therapies, such as intensified insulin treatments, is important in improving glycemic control (60); 4) a minimum threshold of diabetes knowledge is required; and 5) improved personal attitudes and motivations are more effective than knowledge in improving metabolic control (110). Many have also noted the lack of a relationship between SMBG and glycemic control for

Table 6—Effect of self-management training on economic and health care utilization outcomes

Reference	n, F/U interval, and mean age	Interventions	Outcomes	Reordered comments
1. Didactic, knowledge, and information interventions				
34	n = 345; F/U immediate; 58 years	I: Nine multimedia education classes over 1.5 years C: Usual care	NSD sick days, admissions, emergency room or OP visits	No mention blinding assessor Low participation rate; nonparticipants older, more male
65, 109	n = 1,139; F/U 5 years; 46 years	I-1: Didactic individual and group sessions q3 months: focus on diet, PA, smoking, BP and BS control I-2: I-1 + clofibrilic acid C: Usual care at DM clinics, q3–4 months	More sick leave events/year for C vs. I, $P < 0.05$ NSD duration sick leave events	No mention blinding assessor Low participation rates, no information on nonparticipants Clofibrilic acid arm double-blinded
2. Collaborative, knowledge, and information interventions				
40, 60	n = 558; F/U 6 months; 45 years	I-1: Collaborative education by HCW, 3 h/week \times 4 weeks I-2: Same education by fellow patients C: No intervention I based on Fishbein and Ajzen Health Belief Model	NSD quality of life NSD sick days, use of health services, daily insulin dosage, number injections Cost per intervention patient (including indirect costs): \$100	Hospitals randomized I more visits than C Uncertain blinding assessor
46	n = 471; F/U 6, 12 months from BL; 52 years	I: Home visits, teaching based on needs assessment, maximum 12 visits C: Usual care	NSD emergency room and physician visits, hospitalizations, length of stay, DM-related sick days at 1 year	Attrition 20%; no comparison dropouts to completers 70% of eligible participated
54	n = 107; F/U 1, 4 months; 60 years	I: 2 \times 2-h group didactic + practice + feedback + usual care C: Usual care: individual education based on perceived patient need Both in IP setting	Decreased emergency room visits for I vs. C, $P = 0.005$	Randomized by hospital number No blinding assessor No information on participation rates
3. Lifestyle interventions				
67, 68, 104	n = 206; F/U 12 months from BL; 62 years	I: Single visit: focus on diet, goal-setting, interactive video on barriers; F/U q3 months C: Usual care q3 months	Direct costs of intervention \$137 per patient NSD quality of life	Unclear if food record reviewers were blinded Low participation rate; participants differ from nonparticipants
79, 100, 101	n = 76; F/U 3, 6, 18 months from BL; 54 years	I-1: Diet focus: goal-setting, modify environment I-2: PA focus with participation I-3: Diet + PA C: Didactic teaching All groups: 10 \times 2-h weekly sessions: I based on behavior and cognitive modification strategies	Increased quality of life for I-3 at 18 months, $P < 0.05$	Randomized by group meeting attended Volunteer study population
81, 102	n = 203; F/U 6 months from BL; 57 years	I: Three or more individual visits with dietitian, over 6 weeks, following practice guidelines C-1: One visit producing nutrition care plan C-2: Nonrandomized comparison group: no intervention	Cost per % change GHb lower for C; no statistics Cost effectiveness ratio \$56.26 per % change in HbA _{1c}	Nonrandomized C-2 C less time with dietitian Attrition 28% for lab studies, unclear if lab dropouts equal completers at BL Volunteer study population or physician-referred

BL, baseline; BS, blood sugar; BP, blood pressure; C, C-1, C-2, control groups; CAI, computer-assisted instruction; CHO, carbohydrate; D/SBP, diastolic/systolic blood pressure; DM, diabetes mellitus; DM2, type 2 diabetes; FBS, fasting blood sugar; F/U, follow-up; HCW, health-care worker; I, I-1, I-2, I-3, intervention groups; IP, inpatient; NSD, no significant difference; OP, outpatient; PA, physical activity; q, every; RN, registered nurse; SD, significant difference; TC, telephone call.

subjects with type 2 diabetes (111–116), although several randomized controlled trials have shown a relationship in type 1 diabetes (117,118).

The literature is divided regarding the relative merits of group versus individual therapy, and in our review, both types of delivery demonstrated mixed results for interventions that focused on knowledge, lifestyle, or skills. Lifestyle interventions were generally more effective in group settings, with positive outcomes noted for

weight loss (8,36,47,48,72,74,76,77,94) and glycemic control (31,36,71,76,79), although two studies of lifestyle interventions in individual settings had positive effects on weight (38,80). Both individual (38,39,66–68) and group (72,75,93) lifestyle interventions had positive effects on diet and self-care behaviors. It is notable that skills teaching was effective in both group (41,62) and individual settings (45,58).

Others have drawn conclusions simi-

lar to ours about effective interventions in diabetes self-management training. Brown's meta-analyses (9,10) support the effectiveness of diabetes education, with positive effect sizes (from largest to smallest) for the outcomes of knowledge, dietary compliance, skill performance, metabolic control, psychological outcomes, and weight loss. Padgett et al. (11) reviewed the effectiveness of diabetes education in 1988 and found diet instruction and approaches based on social

Effect of Self-Management Training on Glycemic Control

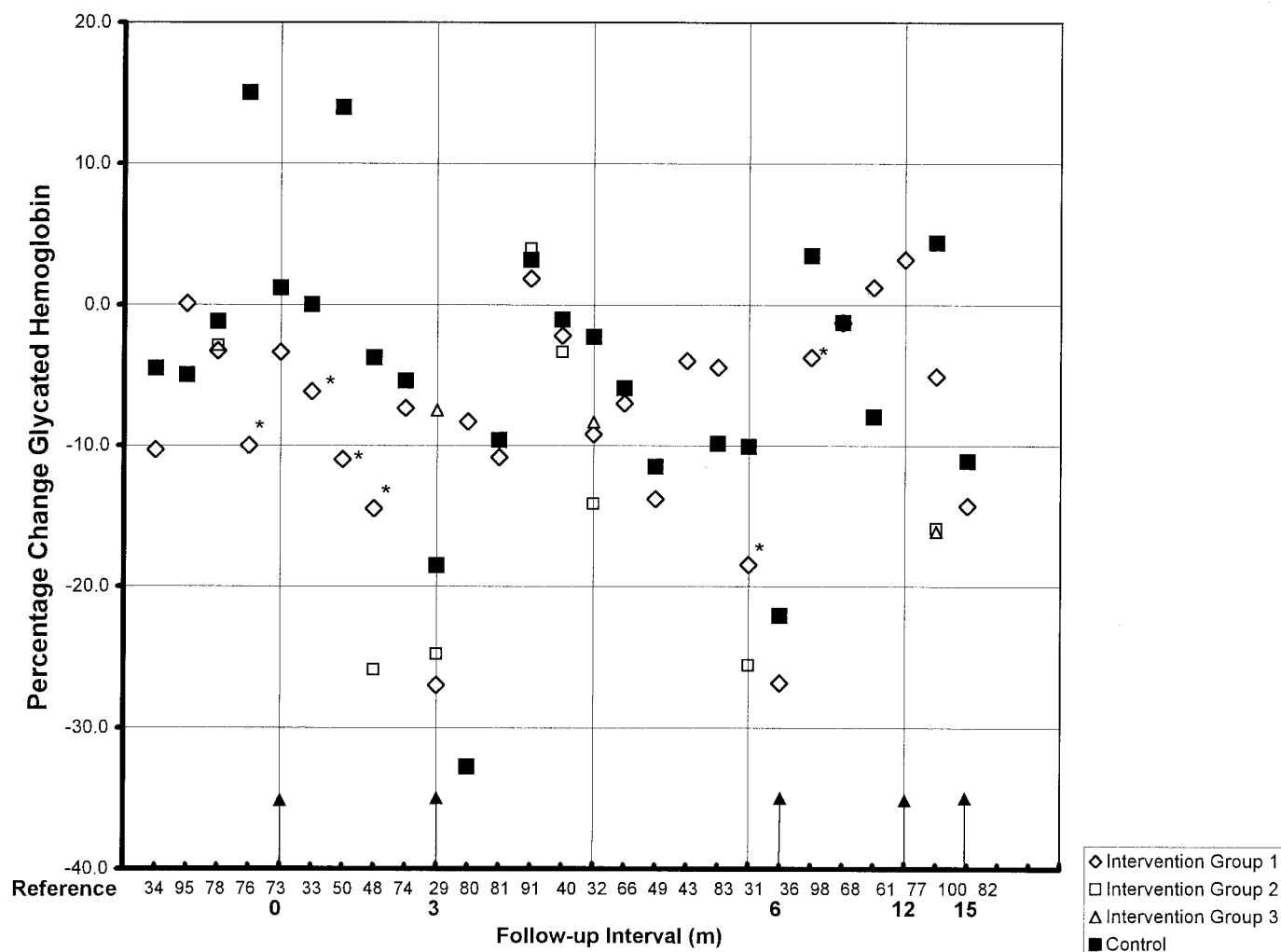


Figure 1—Percentage change in glycated hemoglobin for control and intervention groups for studies referenced on the x-axis. For studies with more than one intervention group, results are shown for each group. Follow-up intervals from end of the intervention are noted on the x-axis, with studies to the left of each arrow having the follow-up interval indicated. *Significant difference between intervention and control groups. m, month.

learning theory to be the most effective interventions; physical outcomes and knowledge were most improved. A qualitative review of diabetes self-management education concluded that behavior change strategies were much more effective than didactic methods and that patient education was most effective when combined with health-care provider medication adjustment and reinforcement of educational messages (5). Anderson (119) noted that effective diabetes-management programs must be noncomplex, individualized to a person's lifestyle, and reinforced over time, and they must respect an individual's habits and routines and incorporate social support. Similar generalizations are found in

reviews of chronic disease care. Von Korff et al. (120) concluded that effective programs in chronic disease care include collaborative problem definition; targeting, goal setting, and planning; a continuum of self-management training and support services; and active and sustained follow-up. Wagner et al. (121) stated that chronic illness programs require psycho-educational programming, and they emphasized the importance of responding to patients' individual needs, readiness to change, and self-efficacy. Mullen et al. (122) noted that the most beneficial components of educational interventions in chronic diseases were individualization, relevance, feedback, reinforcement, and facilitation.

Methodological issues

There are important limitations in execution of many of these studies. Internal validity was frequently threatened by 1) lack of blinding of the assessor, 2) infeasibility of blinding study subjects, 3) high attrition, 4) contamination of the control group, 5) unintended cointerventions, 6) lack of detail on allocation concealment (20), 7) response-set bias whereby intervention group participants report dietary and other habits that match the goals of the intervention rather than actual behavior (123), and 8) deficits in the reliability and validity of the instruments used to measure knowledge, self-care, and dietary habits. Brown (124) has previously noted that the measurement of knowl-

Table 7—Conclusions of a review of randomized, controlled trials of the effectiveness of self-management training in type 2 diabetes**A. Effectiveness of interventions**

1. In the short term (<6 months), knowledge levels, SMBG skills, and self-reported dietary habits improve.
2. In the short term, improvements in glycemic control, knowledge, and diet are more readily demonstrated than improvements in weight and physical activity levels.
3. Improved glycemic control does not correspond to measured changes in knowledge or SMBG skills.
4. Weight loss can be demonstrated with repetitive interventions or with short-term follow-up (<6 months).
5. Physical activity levels are variably affected by interventions.
6. Effects on lipids and blood pressure are variable and more likely to be positive with interactive or individualized, repetitive interventions.
7. Studies with short-term follow-up are more likely to demonstrate positive effects on glycemic control and behavioral outcomes than studies with longer follow-up intervals.
8. Interventions with regular reinforcement are more effective than one-time or short-term education.
9. Interventions that involve patient participation and collaboration seem to produce somewhat more favorable effects on glycemic control, weight loss, and lipid profiles than didactic ones.
10. Group education is more effective for lifestyle interventions and seems to be equally effective for interventions focusing on knowledge and SMBG.
11. The focus of the current literature has been on knowledge and glycemic control outcomes; there is little literature measuring quality of life and long-term clinical outcomes.

B. Methodological issues

1. Descriptive information is frequently lacking, including type of diabetes and the representativeness of study populations to target populations.
2. Threats to internal validity (selection, performance, attrition, and detection bias) are common.
3. Generalizability of study results is often limited by enrollee or researcher selection into study populations or by lack of information on the representativeness of the study population.

C. Potential future research topics

1. Systematic review of the effectiveness of self-management training interventions in patients with type 2 diabetes using study designs other than randomized, controlled trials.
2. Effectiveness studies to define optimal long-term and maintenance interventions with respect to content, frequency, and method of delivery.
3. Studies to further delineate the impact of self-management training on intermediate outcomes, such as self-efficacy, problem-solving, and coping skills, and to better define the relationship between these outcomes and behavior change, glycemic control, and long-term outcomes.
4. Studies examining the feasibility, effectiveness, and cost-effectiveness of population-based self-management training, as compared with individual patient-centered training.
5. Quantitative review of self-management training effectiveness to further examine the heterogeneity of the literature, and the relationships between population characteristics, study design and quality, intervention characteristics, and outcomes.
6. Effectiveness studies focusing on long-term cardiovascular, quality of life, and economic outcomes.

edge is seriously flawed. More recent studies have demonstrated little improvement. In addition, most studies compare a more intensive intervention to basic care and education, as it is generally considered unethical to randomize a group to receive no education, thus minimizing measured effects of the intervention.

There was frequently an inadequate description of study interventions and participants, including the representativeness of study populations. Generalizability was also frequently limited by the volunteer nature of the study populations. Glasgow and Osteen (125) noted similar deficiencies in information on the representativeness of study populations in diabetes self-management training studies, as well as in the reporting of patient characteristics.

The behavioral theories on which interventions were based are documented in a few studies (29,40,60,67,68,79,93,96), as were the behavioral tools (27,30,46,48–50,72,73,75,76–78,91,92,94). However, data are insufficient to determine which behavioral tools and theories are most advantageous.

Although only randomized, controlled trials were reviewed, there is an important body of literature with other study designs. It is more difficult to draw conclusions about causality from nonexperimental designs than from an experimental design (16). Nonetheless, nonexperimental designs, if methodologically sound, reveal important information about the effectiveness of interventions (126). Randomized, controlled trials in this area of research are not always feasi-

ble, or even desirable, particularly when examining community educational interventions. Glasgow et al. (127) note the increasing importance of recognizing the complexity of disease determinants and multilevel system interventions. Classic randomized, controlled trials emphasize efficacy, to the exclusion of factors influencing effectiveness, such as adoption, reach, and institutionalization (127).

This review supports concerns expressed by others that researchers may not be measuring the most important outcomes (125,127). Glasgow and Osteen (125) reviewed Brown's 1990 meta-analysis (10) and concluded that "Program evaluations to date have focused too narrowly on assessing knowledge and GHb outcomes to the exclusion of other important variables." They stated that

process and mediating variables (such as self-efficacy, problem-solving, and coping skills) and quality-of-life outcomes must receive much more attention in intervention research. Unfortunately, our review suggests that little has changed in the past 10 years, as researchers have continued to focus on knowledge and glycemic control to the exclusion of outcomes reflecting a more holistic view of patient function, longevity, and quality of life.

Future research

There are clearly many gaps in the literature on effectiveness of diabetes self-management training in type 2 diabetes (Table 7). More work must be done to identify the predictors and correlates of glycemic control, because knowledge levels and SMBG do not correlate well with blood glucose. Behavioral theory must have a more explicit role in future studies to improve the understanding of behavior change in the self-management of chronic illness. The role of electronic media in diabetes self-management training, the role of nontraditional health-care providers, and the optimal training of health educators has yet to be determined. The role of individual needs assessment within the context of group teaching has not been clarified. Quality-of-life outcomes must be brought to the forefront of future research.

The objectives for ideal self-management interventions in diabetes are clear: behavioral interventions must be practical and feasible in a variety of settings; a large percentage of the relevant population must be willing to participate; the intervention must be effective for long-term important physiological outcomes, behavioral end points, and quality of life; patients must be satisfied; and the intervention must be relatively low-cost and cost-effective (68). How best to achieve these objectives is not entirely clear. There are some well-designed and -executed studies that support the effectiveness of self-management training for patients with type 2 diabetes, particularly in the short term. The challenge is to expand upon this current knowledge to achieve all of the objectives of ideal self-management. Further research of high methodological quality in diverse study populations and settings and using generalizable interventions is needed to assess the effectiveness of self-management interventions on sustained glycemic con-

trol, cardiovascular disease risk factors, and ultimately, microvascular and cardiovascular disease and quality of life.

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Prevention of Type 2 Diabetes in Women With Previous Gestational Diabetes

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The consequences of hyperglycemia appearing during pregnancy were well described in 1917, when Elliot P. Joslin described Case 309, which “showed sugar in 1897 during pregnancy, but following confinement, with resulting dead baby, it disappeared, but returned in 9 years in the form of moderate to severe diabetes. . . . [W]ith our present knowledge, it is quite possible that such an outcome could be prevented by active treatment of the glycosuria from the very start” (1). Subsequently, O’Sullivan and Mahan’s definition of gestational diabetes mellitus (GDM) in 1964 was a formal recognition of the mother’s increased risk of future development of diabetes (2). They defined GDM if a pregnant woman undergoing a 3-h 100-g oral glucose tolerance test had glucose values exceeding 2 SDs above the mean on two of the four values. This landmark study described a population of pregnant women with a lifetime risk of diabetes exceeding 70% (3). Multiple studies worldwide have demonstrated a broad ethnic and geographic distribution of GDM, but all studies share the increased risk of subsequent diabetes after delivery (4).

PREVALENCE OF DIABETES AFTER GDM

— Assessment of diabetes risk postpartum is influenced by the criteria used to define GDM, the testing undertaken postpartum, and the length of follow-up. Diagnosis of carbohydrate intolerance in the first trimester of pregnancy may reflect the ascertainment of previously undiagnosed and, presumably, asymptomatic diabetes. Alternatively, pregnancy creates a metabolic

stress that may push a woman with compensated type 1 or type 2 diabetes into a decompensated hyperglycemic state. Under these circumstances, one would anticipate a high rate of persistent hyperglycemia in the postpartum state. In fact, the presence of GDM doubles the risk of diabetes within 4 months postpartum, whereas a fasting plasma glucose >121 mg/dl during the pregnancy increased the risk 21-fold (5).

Differential criteria for diagnosis of GDM affects the denominator for the assessment of proportion of women affected (6). Reliance on fasting glucose screens with failure to perform oral glucose tolerance tests reduces the sensitivity of identifying subsequent diabetes (7). At the Fifth International Workshop, Kitzmiller presented data from a multiethnic cohort further demonstrating the limitations of the fasting glucose as a screen, with only 34% of impaired glucose tolerance or diabetes being picked up by those women with impaired fasting glucose levels (J.L. Kitzmiller, personal communication). As will be shown subsequently, there does not appear to be a temporal window for postpartum diabetes development, but rather the risk persists, requiring lifelong evaluation to completely capture the risk of diabetes.

A systematic review of GDM and ensuing diabetes was published by Kim et al. (8). The review encompassed 36 years and included studies that specified the criteria for the diagnosis of both GDM and type 2 diabetes and included the risk of diabetes in women with a history of GDM. A total of 28 studies met criteria, and together they demonstrate a consistent pat-

tern of diabetes occurrence over time. Differences among studies were explained by differential follow-up, ethnicity, and retesting rates. When cumulative incidence of diabetes is plotted against follow-up after delivery (Fig. 1), rapid conversion to diabetes is seen over the first 5 years, with a slower progression subsequently.

The Diabetes Prevention Program (DPP) sought involvement of women with a history of GDM and impaired glucose tolerance to participate in a long-term diabetes prevention study (9). A total of 350 women (of 1,810 parous women randomized) provided a history of GDM with a mean of 12 years since the index GDM pregnancy. Women who rapidly transitioned from GDM to type 2 diabetes before entry into the DPP were excluded from entry, yielding a survival cohort of high-risk women who had impaired glucose tolerance. Women with a history of GDM were 8 years younger than the non-GDM cohort, but were otherwise well matched for ethnicity, parity, BMI, level of glucose intolerance, or insulin resistance. Even after adjusting for age (Fig. 2), the women with a history of GDM in the placebo group had a 74% increased hazard for developing diabetes than their non-GDM control subjects (17.1%/year compared with 9.8%/year over 3 years, respectively) (10). So, even temporarily removed from the index pregnancy, GDM confers a markedly increased risk for developing diabetes, even when compared with a comparably glucose-intolerant population.

PREDICTORS OF TYPE 2 DIABETES AFTER GDM

— As previously mentioned, fasting plasma glucose is the strongest predictor of early postpartum development of diabetes (5), but it also remains the strongest independent predictor of long-term development of type 2 diabetes in the mother (8). Area under the oral glucose tolerance test curve, as well as 1- and 2-h glucose levels, typically correlate with diabetes risk, as well.

Once these glycemic parameters are controlled for in multivariate analysis, maternal BMI, either before or during pregnancy, correlated with diabetes risk,

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Abbreviations: ACOG, American College of Obstetrics and Gynecology; DPP, Diabetes Prevention Program; GDM, gestational diabetes mellitus; PIPOD, Pioglitazone in Prevention of Diabetes; TRIPOD, Troglitazone in Prevention of Diabetes.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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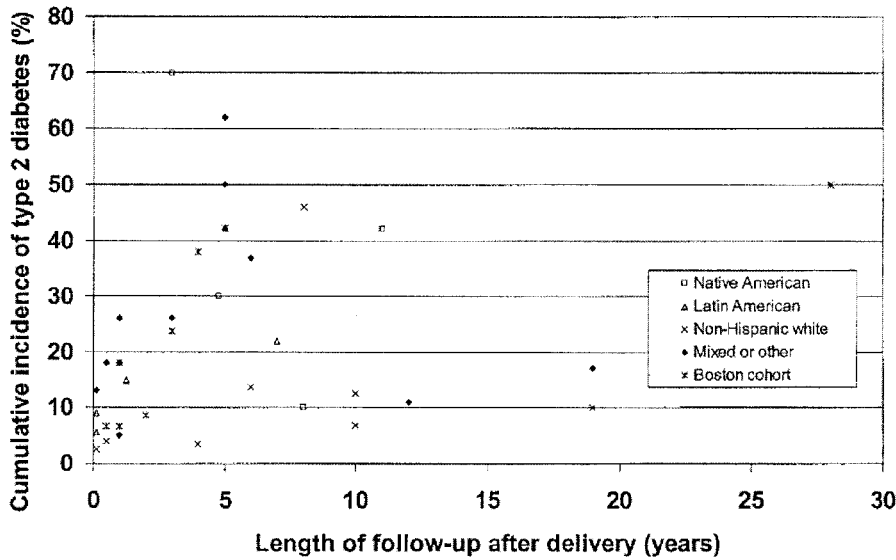


Figure 1—Cumulative incidence of type 2 diabetes by ethnicity and length of follow-up. Adapted from Kim et al. (8).

but neither gestational weight gain nor postpartum BMI remained significant predictors. Similarly, maternal age, parity <5, prior GDM, or family history of diabetes are not independently associated with subsequent diabetes in multivariate analysis when glycemic variables are included (8,11,12). Insulin therapy during pregnancy frequently predicts subsequent maternal diabetes (13), but may simply be a reflection of the degree of fasting hyperglycemia. Fetal outcomes have not been predictive of maternal risk of diabetes.

Although not routinely obtained, assessment of insulin secretion, both during and after pregnancy, provides the strongest independent predictors of diabetes in the mother (14,15). Perhaps the best pathophysiological assessment of predictors of progression to diabetes after GDM stem from the Troglitazone in Prevention of Diabetes (TRIPOD) study of Buchanan et al. (16). Protection from conversion to type 2 diabetes was conferred by a reduction in insulin resistance, resulting in large reductions in insulin output. They concluded that reduction in β -cell workload may preserve subsequent β -cell function. This was further explored in the open-label observational study, Pioglitazone in Prevention of Diabetes (PIPOD), in which lower glucose levels and higher acute insulin responses during an intravenous glucose tolerance test were seen in women remaining diabetes free (17). Independent predictors of diabetes development were the lack of change in insulin

area after the intravenous glucose tolerance test in the first year of follow-up and the higher the baseline oral glucose tolerance test glucose area.

CURRENT RECOMMENDATIONS FOR POSTPARTUM FOLLOW-UP

At the present time, the American Diabetes Association on the basis of expert consensus recommends that “women with gestational diabetes should be screened for diabetes 6 weeks postpartum and should be followed up with subsequent screening for the development of diabetes or pre-diabetes” (18).

The American College of Obstetrics and Gynecology (ACOG) makes no specific recommendation on follow-up other than to suggest that postpartum testing may be performed, despite the absence of data demonstrating a clear benefit (19). Survey data suggest that 75% of practicing obstetricians who are ACOG fellows routinely test patients with GDM in the postpartum state (20); however, a more detailed chart review revealed far fewer women with GDM actually receive any glucose follow-up (21). Two-thirds of women with GDM history underwent some form of glycemia assessment at a mean of 136 days postpartum. Only 37% underwent either a fasting glucose or oral glucose tolerance test at a median of ~14 months after delivery.

Recommendations for actual intervention to prevent progression to diabetes are even less clear. Without clearly specifying GDM as a risk factor, the American Diabetes Association (18) recommends the following: 1) individuals at high risk for developing diabetes need to become aware of the benefits of modest weight loss and participating in regular physical activity, and 2) monitoring for the development of diabetes should be performed every 1–2 years.

ACOG suggests that “individuals at increased risk should be counseled regarding diet, exercise, and weight reduction or maintenance to forestall or prevent the onset of type 2 diabetes” (19).

The National Diabetes Education Program (NDEP) is currently promoting a GDM Diabetes Prevention Initiative, targeting both providers and women with a

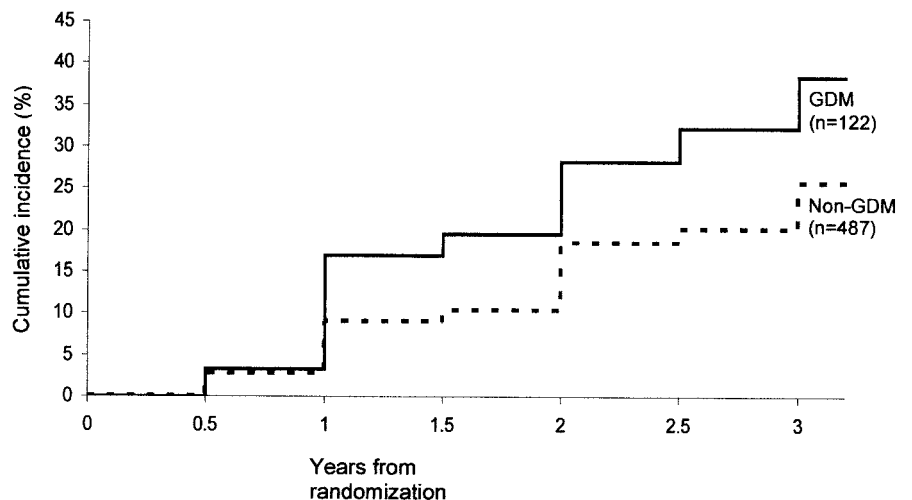


Figure 2—Cumulative incidence of diabetes among the placebo group (adjusted for age in DPP by history of GDM). Adapted from the Diabetes Prevention Program Research Group (10).

Table 1—GDM diabetes prevention initiative from the National Diabetes Education Program

- GDM imparts lifelong risk for diabetes, mostly type 2.
- Modest weight loss and physical activity can delay or prevent type 2 diabetes.
- Offspring can lower risk by eating healthy foods, being active, and not becoming overweight.

Conservative recommendations to patients include:

- Let health care practitioners know of any history of GDM.
- Get tested 6–12 weeks postpartum, then every 1–2 years.
- Reach prepregnancy weight 6–12 months postpartum.
- If still overweight, lose at least 5–7% of weight slowly, over time, and keep it off.

Adapted from the National Diabetes Education Program (22).

GDM history (22). Key messages are illustrated in Table 1.

The rationale for such recommendations is now being developed from a variety of clinical trials; however, these are based on clinical expert committee recommendations.

CLINICAL TRIALS INTERVENING POSTPARTUM TO PREVENT OR DELAY DIABETES

Of the six published diabetes prevention clinical trials, three specifically targeted and analyzed women with a history of GDM. The TRIPOD study exclusively enrolled women with prior GDM, regardless of impaired glucose tolerance or normal glucose tolerance (16). Women were obese (mean BMI 30 kg/m²), with approximately two-thirds with impaired glucose tolerance at study entry and the rest with normal glucose tolerance. Randomization to placebo or troglitazone treatment demonstrated a 55% risk reduction in the development of diabetes in the troglitazone group from 12.1%/year for placebo to 5.4%/year. The early termination of the trial, because of the recall of troglitazone from the market, provided a unique opportunity to assess the durability of the benefit and to clarify whether hyperglycemia was simply being treated or actually prevented. With 86% ascertainment at ~8 months after discontinuation of the

interventions, incidence rates for diabetes remained highly significantly different with a risk reduction for troglitazone therapy of 87% (21.2%/year down to 3.1%/year). The authors conclude that delay or prevention, rather than masking, occurred as a result of the active intervention.

With the withdrawal of troglitazone therapy from the American market, the issue of comparable response post-GDM to therapy with other available thiazolidinediones was studied in the observational PIPOD study (17). Women completing the TRIPOD study without developing diabetes were invited to participate and were given 30 mg pioglitazone and titrated to 45 mg daily. Over the subsequent 3 years, the incidence of diabetes was 4.6%/year compared with the historical observation of 12.1% diabetes per year in the placebo group of TRIPOD. Without the concurrent control group, these data only infer a durable effect of thiazolidinedione therapy, since they were comparable to the 3.1%/year incidence seen with troglitazone. PIPOD further substantiated that the protective effect of thiazolidinediones lies in their capacity to offload the β-cell by preventing the 33% reduction in β-cell compensation for insulin resistance seen during TRIPOD.

The DPP was a multicenter clinical trial of both men and women with im-

paired glucose tolerance randomized to receive standard lifestyle intervention and placebo, metformin therapy, or an intensive lifestyle intervention (9). The population enrolled included a multiethnic population spanning the age range of 25–89 years (23). As previously reported for the cohort as a whole, intensive lifestyle intervention delayed or prevented the onset of diabetes in 58%, whereas metformin was successful in 31%, compared with the placebo control group (24). As previously stated, the women with a GDM history enrolled in the DPP were younger, but otherwise comparable to those women without the GDM history (10). Despite less weight loss resulting from intensive lifestyle intervention, the women with GDM histories had a comparable reduction in the development of diabetes (55%). Metformin therapy was even more effective in the GDM cohort, with a 50% risk reduction, compared with 14% in the non-GDM group. This latter finding may be explained by the younger age of those with a history of GDM and the previously identified relationship between age and metformin response (24).

CONCLUSIONS — In summary, it is clear that GDM confers a lifelong increased risk for the development of diabetes, and in most cases, this turns out to be type 2 diabetes. Progression from GDM to type 2 diabetes correlates with progressive β-cell failure to compensate for the ongoing insulin resistance. Postpartum follow-up of at-risk women is inadequate, and the recommendations for screening from ACOG and the American Diabetes Association are at variance. Consistent recommendations, together with a professional and public health campaign to raise the awareness of GDM as a diabetes predictor, will be necessary to improve postpartum care of women at highest risk.

Table 2—Metabolic assessments recommended after GDM

Time	Test	Purpose
After delivery (1–3 days)	Fasting or random plasma glucose	Detect persistent, overt diabetes
Early postpartum (around the time of postpartum visit)	75 gm 2-hr OGTT ¹	Postpartum classification of glucose metabolism*
1 year postpartum	75 gm 2-hr OGTT ¹	Assess glucose metabolism
Annually	Fasting plasma glucose	Assess glucose metabolism
Tri-annually	75 gm 2-hr OGTT ¹	Assess glucose metabolism
Prepregnancy	75 gm 2-hr OGTT ¹	Classify glucose metabolism*

Reproduced from the Summary and Recommendations of the Fifth International Workshop-Conference on Gestational Diabetes Mellitus (25). OGTT, oral glucose tolerance test. *Classification of glucose metabolism by criteria recommended by the American Diabetes Association (19).

Recommendations for follow-up of GDM stemming from the Fifth International Workshop-Conference are elucidated elsewhere in this publication, but are summarized in Table 2.

Clinical trials now provide level A evidence for the impact of multiple interventions to prevent the progression to type 2 diabetes in women with a history of GDM. Both lifestyle modification and pharmacological therapies (metformin, troglitazone, and pioglitazone) have been shown to reduce diabetes development by 50% or more. The diagnosis of GDM should initiate a long-term intervention and diagnostic process to minimize the risk of developing diabetes or to diagnose it as early in the course of disease as possible.

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Rates and Risk Factors for Recurrence of Gestational Diabetes

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OBJECTIVE — To determine the recurrence rate of gestational diabetes (GDM) during a subsequent pregnancy among women who had GDM during an index pregnancy and to identify factors associated with the probability of recurrence.

RESEARCH DESIGN AND METHODS — A retrospective longitudinal study was performed in Nova Scotia, Canada, of women who were diagnosed as having GDM during a pregnancy between the years of 1980 and 1996 and who had at least one subsequent pregnancy during this time period. When only the index and first subsequent pregnancy were analyzed, the cohort included 651 women. The recurrence rate of GDM in the pregnancy after the pregnancy with the initial diagnosis of GDM was determined. Multivariate regression models were constructed to model the recurrence of GDM in a subsequent pregnancy as functions of potential predictors to estimate RRs and CIs.

RESULTS — The rate of recurrence of GDM in the pregnancy subsequent to the index pregnancy was found to be 35.6% (95% CI = 31.9–39.3%). Multivariate regression models showed that infant birth weight in the index pregnancy and maternal prepregnancy weight before the subsequent pregnancy were predictive of recurrent GDM.

CONCLUSIONS — In this large cohort of women, slightly more than one-third of the subjects had diabetes in a subsequent pregnancy, which is consistent with recurrence rates in other predominately white populations. Strategies to reduce the occurrence of neonatal macrosomia and maternal prepregnancy obesity may help lower the rate of recurrence of GDM.

Diabetes Care 24:659–662, 2001

It is estimated that gestational diabetes (GDM) recurs in 30–69% of subsequent pregnancies after a pregnancy with GDM (1–6). One of the major risk factors for developing GDM is having had a previous pregnancy complicated by the disease. Other factors that have been identified as predictive of recurrent GDM include obesity, multiparity, early diagnosis of GDM during the initial pregnancy, need for insulin during the initial pregnancy, macrosomia during the initial pregnancy, advanced maternal age, maternal prepregnancy weight during the

initial pregnancy, and an increase in prepregnancy weight between the initial and subsequent pregnancies.

Whereas previous studies have provided useful information regarding recurrence rates and factors predictive for recurrent GDM, they have been limited by relatively small numbers of subjects. The purpose of this study was to examine the recurrence rates of GDM in a large population-based cohort of women who had GDM during an initial pregnancy and to examine factors associated with recurrence.

RESEARCH DESIGN AND METHODS

— The cohort was identified from the Nova Scotia Atlee Perinatal Database (NSAPD) and included Nova Scotia residents who delivered an infant weighing >500 g between 1980 and 1996. In Nova Scotia, there are ~10,000 births per year. The NSAPD includes information on all Nova Scotia hospital deliveries as well as out-of-province deliveries among Nova Scotia residents. Between 1980 and 1987, the study cohort included only Halifax County residents, but since 1988, all residents of Nova Scotia have been included. Data in the NSAPD are abstracted from hospital medical records by trained health records personnel after discharge from hospital. Standardized data collection forms, developed as clinical tools for the prenatal, intrapartum, and postpartum periods, are used throughout the province and ensure that information is collected consistently. The database includes extensive information on maternal medical conditions, labor and delivery events, and neonatal outcomes and some information on lifestyle and demographic factors. Periodic reabstraction studies and validation studies (7) are conducted as part of an ongoing data quality assurance program and have shown that the information in the database is reliable.

Women included in this study had a pregnancy with a diagnosis of GDM and at least one subsequent pregnancy. Women with preexisting diabetes diagnosed before their index pregnancy were not considered to have GDM and were not included in this study. Information pertaining to all pregnancies subsequent to the pregnancy with the initial diagnosis of GDM (referred to as the index pregnancy) was collected. In Nova Scotia, pregnant women are screened for GDM between 24 and 28 weeks' gestation using a 50-g glucose challenge with a 1-h venous plasma glucose. Women with known risk factors, including history of GDM in a previous pregnancy, are often screened earlier. A plasma glucose level of ≥ 7.8 mmol/l is considered positive and warrants the diagnostic test for GDM. The diagnosis of GDM is made if a woman has

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Abbreviations: GDM, gestational diabetes; NSAPD, Nova Scotia Atlee Perinatal Database.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

two or more abnormal values on a 3-h 100-g oral glucose tolerance test using the O'Sullivan criteria (8). Diagnostic criteria for the oral glucose tolerance test include the following: fasting ≥ 5.3 mmol/l; 1 h ≥ 10.6 mmol/l; 2 h ≥ 9.2 mmol/l; 3 h ≥ 8.1 mmol/l. Women with GDM in an index pregnancy who developed diabetes in the interval between pregnancies were included in this study.

Statistical analyses were performed using S-Plus (Statistical Sciences, Seattle, WA) and Epi Info (Centers for Disease Control and Prevention, Atlanta, GA) software. Possible predictors were initially analyzed in a univariate fashion by estimating RRs and 95% CIs. Next, potential predictors were modeled using stepwise logistic regression. From the index pregnancy, birth weight of the infant, weight gain during the pregnancy, maternal age, and breast-feeding were considered. Variables from the subsequent pregnancy included smoking, maternal age, prepregnancy weight, and predelivery weight. Weight change between the two pregnancies (defined as the change in prepregnancy weight between the index and subsequent pregnancies) and the time interval between the two pregnancies (defined as the number of months between the date of delivery of the index pregnancy and the date of delivery of the subsequent pregnancy) were also evaluated. Because the recurrence of GDM is estimated to be $>30\%$, odds ratios calculated from a logistic model will overestimate the RR. Therefore, odds ratios were converted to RRs using log-linear models with a binary error term (9).

RESULTS — This study included 651 women who had a diagnosis of GDM during an index pregnancy and then had a subsequent pregnancy. For 68% of these women, the index pregnancy was the first pregnancy, and for 20% of these women, the index pregnancy was the second pregnancy. Of the 651 women in the study who had GDM during an index pregnancy, 232 (35.6%) had diabetes during the subsequent pregnancy (95% CI 31.9–39.3%). Of the 232 women, 16 developed diabetes in the interval between the index and subsequent pregnancies.

A comparison of potential risk factors among women who had a GDM recurrence and those who did not are shown in Table 1. In a univariate analysis, all of the variables related to maternal weight, ex-

Table 1—Univariate associations between recurrence of GDM and factors from the index and subsequent pregnancy

Variable	n*	Recurrence of GDM n (%)	RR (unadjusted)	95% CI
Pregnancy weight: index pregnancy				
<120 lb	108	30 (27.8)	1.00	—
120–149 lb	190	60 (31.6)	1.14	(0.79–1.64)
150–189 lb	163	55 (33.7)	1.21	(0.84–1.76)
≥ 190 lb	86	44 (51.2)	1.84	(1.28–2.66)
Pregnancy weight: subsequent pregnancy				
<120 lb	83	22 (26.5)	1.00	—
120–149 lb	206	62 (30.1)	1.14	(0.75–1.72)
150–189 lb	158	56 (35.4)	1.34	(0.88–2.03)
≥ 190 lb	113	57 (50.4)	1.90	(1.27–2.85)
Birth weight: index pregnancy				
2,500–3,999 g	473	152 (32.1)	1.00	—
<2,500 g	39	12 (30.8)	0.96	(0.59–1.56)
$\geq 4,000$ g	139	68 (48.9)	1.52	(1.23–1.89)
Breast-feeding: index pregnancy				
Yes	347	117 (33.7)	1.00	—
No	293	109 (37.2)	1.10	(0.89–1.36)
Predelivery weight: index pregnancy				
<145 lb	83	21 (25.3)	1.00	—
145–179 lb	197	59 (29.9)	1.18	(0.77–1.81)
180–219 lb	178	68 (38.2)	1.51	(1.00–2.28)
≥ 220 lb	82	38 (46.3)	1.83	(1.18–2.84)
Predelivery weight: subsequent pregnancy				
<145 lb	75	20 (26.7)	1.00	—
145–179 lb	204	67 (32.8)	1.23	(0.81–1.88)
180–219 lb	176	62 (35.2)	1.32	(0.86–202)
≥ 220 lb	97	47 (48.5)	1.82	(1.18–2.79)
Smoking: index pregnancy				
No	396	139 (35.1)	1.00	—
Yes	166	61 (36.7)	1.05	(0.82–1.33)
Weight change between pregnancies				
<0 lb	141	48 (34.0)	1.00	—
0–4 lb	103	36 (35.0)	1.03	(0.72–1.46)
5–19 lb	174	53 (30.5)	0.89	(0.65–1.23)
≥ 20 lb	72	30 (41.7)	1.22	(0.86–1.75)
Weight gain during pregnancy:				
index pregnancy				
<15 lb	58	25 (43.1)	1.00	—
15–29 lb	210	76 (36.2)	0.84	(0.59–1.19)
30–44 lb	179	59 (33.0)	0.76	(0.53–1.10)
≥ 45 lb	74	18 (24.3)	0.56	(0.34–0.93)

*Numbers do not add up to total for some factors because of missing values.

cept weight change between pregnancies, were significantly associated with GDM recurrence, regardless of whether they pertained to the index or subsequent pregnancy. The mean age of the mother at either the time of the index pregnancy or at the time of the subsequent pregnancy was not different among those who had recurrent GDM and those who did not, as

tested by Student's *t* test. In addition, there was no difference in the mean number of months between pregnancies among those in whom GDM recurred and those in whom it did not. When all potential predictors were analyzed in a logistic model, only infant birth weight from the index pregnancy and maternal prepregnancy weight from the subse-

Table 2—Predictive factors for recurrence of GDM from the multivariate model

Variable	Recurrence of GDM n (%)	Adjusted RR (95% CI)*
Prepregnancy weight (subsequent pregnancy)		
<120 lb	22 (26.5)	1.0
120–149 lb	62 (30.1)	1.1 (0.7–1.6)
150–189 lb	56 (35.4)	1.2 (0.8–1.9)
≥190 lb	57 (50.4)	1.7 (1.2–2.6)
Infant birth weight (index pregnancy)		
2,500–3,999 g	152 (32.1)	1.0
<2,500 g	12 (30.8)	0.9 (0.5–1.5)
≥4,000 g	68 (48.9)	1.4 (1.1–1.8)

*Adjusted for other term in model.

quent pregnancy significantly contributed to the fit of the model predicting GDM recurrence. As shown in Table 2, women who had a macrosomic infant ($\geq 4,000$ g) from their index pregnancy were 40% more likely to have a recurrence compared with women whose infant was 2,500–3,999 g. Women whose prepregnancy weight at the start of the subsequent pregnancy was ≥ 190 lb were 70% more likely to have a recurrence of GDM, adjusting for infant birth weight in the index pregnancy. A statistically significant trend was seen with both prepregnancy weight and infant birth weight when they were modeled as continuous variables.

Further analysis involved an examination of the first and second subsequent pregnancies after the index pregnancy. As shown in Fig. 1, the rate of recurrence in the second subsequent pregnancy was 72.4% among those who had GDM during both the index pregnancy and the first subsequent pregnancy and 21.5% among those who had GDM during an

initial pregnancy but did not have GDM recurrence during the first subsequent pregnancy.

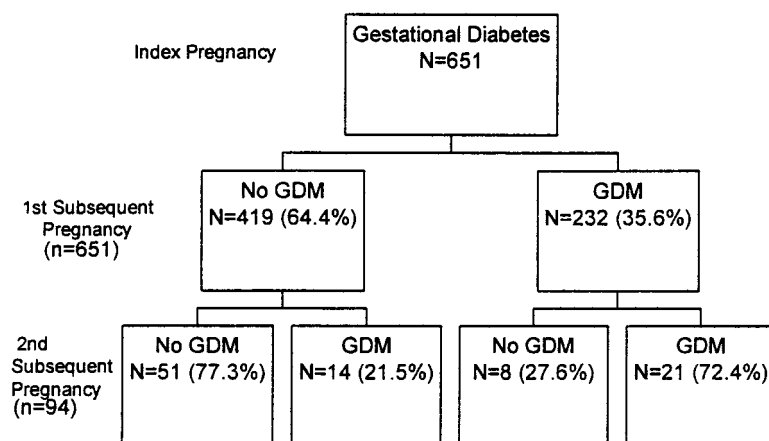
CONCLUSIONS— This study describes the recurrence rates of GDM among a large cohort of women who had GDM during an initial pregnancy. The recurrence rates found in this study (35.6%) are comparable with results seen in three previous studies (3–5) but lower than the recurrence rates found in three others (1,2,6). The various rates of GDM recurrence seen in the different studies could reflect differences in the underlying population or differences in the diagnostic criteria. In the three previous studies with recurrence rates of $\geq 50\%$ (3–5), the study populations were largely nonwhite. This is in contrast to the studies that reported recurrence rates of ~ 30 – 35% (1, 2,6), including the present study, in which the study populations were predominantly white. Thus, race is likely a risk fac-

tor for GDM as well as a risk factor for the recurrence of GDM (10).

Until 1989, the rates of GDM in Nova Scotia were $< 2\%$; since 1989, the yearly GDM rates have ranged from 2.1 to 3.4%. Since the late 1980s, universal screening for GDM has been the recommended standard of care in Nova Scotia. The increase in the rates of GDM likely reflects increased compliance with this recommendation. Before 1989, when universal screening became the standard of care, it is possible that some diagnoses of GDM during index pregnancies had been missed. However, the relatively low recurrence rates observed in this study are not likely explained by the changes in screening during the study period. More complete population screening would detect women with less severe cases of glucose intolerance who are probably less prone to recurrence of GDM during a subsequent pregnancy. In addition, the criteria for diagnosing GDM have not changed in Nova Scotia during the study period.

The data from this study cannot directly explain the relatively low recurrence rate found in this and other studies. Because the perinatal database does not include information on severity or control of GDM, we could not assess the relationship between these factors and the likelihood of recurrence. However, if women with very severe cases of GDM during the initial pregnancy had been deterred from having a subsequent pregnancy, potential cases of recurrent GDM may have been avoided. Another possible explanation for the relatively low recurrence rates is that women with GDM during an index pregnancy may have been motivated to make dietary modifications before and during the subsequent pregnancy, thereby lowering their risk of recurrent GDM.

The factors that were identified in this study as predictive of recurrent GDM, large infant birth weight and prepregnancy weight ≥ 190 lb, have been found in previous studies. Large infant birth weight during the index pregnancy may be indicative of poor control and/or poor maternal diet or may reflect GDM severity, which may then predispose women to recurrent GDM. Prepregnancy weight is based on self-report at the time of the first prenatal visit, which makes it susceptible to misclassification. It has been suggested that women underreport their prepregnancy weight by 0.8 kg, on average (11). This degree of misclassification is not

**Figure 1—Recurrence of gestational diabetes in subsequent pregnancies**

likely to have a large effect on the relationship between prepregnancy weight of ≥ 190 lb and recurrent GDM. Other studies have found that weight gain between pregnancies is an important predictor of recurrent GDM, but in this study, weight gain did not predict recurrence independently of prepregnancy weight. In a recent Nova Scotia study evaluating the perinatal effects of weight changes between pregnancies, it was found that weight gain between pregnancies was a risk factor for GDM during the subsequent pregnancy, whether it was recurrent GDM or an initial diagnosis (12).

Moses et al. (13) found that women with recurrent GDM during a subsequent pregnancy had higher fat intake compared with women in whom GDM did not recur. This finding was based on a small number of women, and the dietary assessment was conducted several years after the subsequent pregnancy. However, it is consistent with our finding that maternal weight ≥ 190 lb at the start of the subsequent pregnancy is a factor for recurrence. These findings raise further hypotheses to be tested and suggest that dietary manipulation is a potential direction for research aimed at reducing the recurrence of GDM.

Because of the large sample size of this study, we were able to provide stable estimates of recurrence of GDM in a predominantly white population. In addition,

several risk factors for developing recurrent GDM have been confirmed. This information will assist health care providers in counseling women with GDM about their recurrence risk and the importance of appropriate prenatal screening in subsequent pregnancies. Consequently, early detection and management of recurrent GDM may be enhanced.

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