Computer-Aided Diabetes Education:
A Synthesis of Randomized Controlled Trials
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Computer-aided diabetes education is the
typeology to provide information on
diabetes self-management as well as test the users’
knowledge and provide feedback. The objective of
this paper was to evaluate the impact of computer-
aided diabetes education in improving health
outcomes. We identified reports of randomized
controlled trials through systematic electronic
database searches. Three eligibility criteria were
applied: randomized controlled trial; evaluation of a
computerized diabetes education program; and
assessment measured on the outcome of patient care.
Of 19 eligible trials, 16 trials (84.2%) reported
significant positive outcomes. A total of 112
outcomes were identified. Forty-two percent (42.0%)
of the outcomes demonstrated significant
improvements (47 of 112 outcomes). Considering the
importance of patient self-management behaviors in
chronic disease management, initial evidence
suggests computer-aided diabetes education can play
a more significant role in the future.

INTRODUCTION

In the United States, 7% of the population (20.8
million people) has diabetes.¹ Approximately 6.2
million people (30% of 20.8 million) are not aware
that they have diabetes.¹ Diabetes is the fifth leading
cause of death and accounted for $132 billion in
direct and indirect medical expenditures in 2002.²
Roughly, one third of Americans born in 2000 will
develop diabetes in their lifetime.¹ Many people are
not aware that they have diabetes until they have
developed one of its life-threatening complications.¹

Quality health care requires effective
 collaboration between patients and clinicians.
Diabetes education is the cornerstone of effective
diabetes care.³ Computerized knowledge
management and education can become an important
component of quality diabetes care.⁴,⁵ Technology
can assist with the provision of tailored and
personalized education, feedback, and goal setting,
thereby facilitating patient-centered care.

The goals of this study were to identify
automated diabetes education interventions that can
empower patients in the self-management of diabetes
and support diabetes education over a distance. We
systematically reviewed randomized controlled trials
to evaluate the impact of computer-aided diabetes
education on health outcomes. This review was a
preliminary step to a larger project.

METHODS

Data Sources
We searched MEDLINE (1966-2006), CINAHL
(1982-2006), and the Cochrane Central Register of
Controlled Trials (1st Quarter 2006) for relevant
studies using combinations of the following search
terms: (i) diabetes mellitus (MeSH) or Type 2
diabetes mellitus (MeSH) or Type 1 diabetes mellitus
(MeSH); (ii) computer-assisted instruction (MeSH)
or computer (truncated textword); and (iii)
randomized controlled trial (publication type). We
also systematically searched the reference lists of
included studies and relevant reviews.

Inclusion and Exclusion Criteria
Our inclusion criteria were any randomized
controlled trial evaluating a computerized diabetes
self-management education program with assessment
measured on the outcome of patient care. We
excluded studies that were not randomized, had no
control group, were planned studies, or were not in
English.

Study Selection and Data Extraction
Two of the investigators independently reviewed
the titles and abstracts of the identified citations and
applied a screening algorithm based on the inclusion
and exclusion criteria described above. The two
investigators rated each paper as “potentially
relevant” or “potentially not relevant.” The
investigators collected data from each “potentially
relevant” article including educational content topics
and outcomes. For each article, the investigators
noted the patient sample, intervention, outcome
measures, and statistical significance. For the
purposes of this study, a trial was successful only if
### Table 1. Computer-aided diabetes education trials

<table>
<thead>
<tr>
<th>Trial, Year</th>
<th>Sample</th>
<th>Control Care</th>
<th>Intervention Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloomfield et al⁰ 1990</td>
<td>48 children (type 1)</td>
<td>Routine clinic care (average of 5 visits per year)</td>
<td>Computer-based “diabetic club” educational program, 10 sessions</td>
</tr>
<tr>
<td>Estabrooks et al¹⁰ 2005 *</td>
<td>422 adults (type 2)</td>
<td>Usual care, no goal setting</td>
<td>Computerized touch-screen CD-ROM with goal printout and feedback; counseling session with care manager; telephone follow-up</td>
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<tr>
<td>Gerber et al¹¹ 2005</td>
<td>244 adults (type 2)</td>
<td>Simple multimedia application with quizzes; no formal instruction</td>
<td>Computerized touch-screen multimedia with formal instruction and testimonials; feedback</td>
</tr>
<tr>
<td>Glasgow et al¹⁶–¹⁹ 2004, 2005</td>
<td>886 adults (type 2)</td>
<td>Touch screen computer assessment, printout with general health risks</td>
<td>Touch screen computer assessment and action plan, detailed printout, meeting with care manager</td>
</tr>
<tr>
<td>Glasgow et al²⁰–²³ 2000, 2002</td>
<td>320 adults (type 2)</td>
<td>Computerized assessment with goals printout, general pamphlet about low-fat eating</td>
<td>Computerized touch-screen assessment with goals printout, telephone follow-up, community resources</td>
</tr>
<tr>
<td>Graue et al²⁴ 2005</td>
<td>116 children (type 1)</td>
<td>Traditional out-patient consultations (30 min session every 3 months)</td>
<td>Computer-assisted consultations and group visits (3 3-hr sessions every 3 months)</td>
</tr>
<tr>
<td>Levetan et al²⁵ 2002 *</td>
<td>150 adults (type 2)</td>
<td>Usual advice from physician, no additional diabetes education</td>
<td>Computer-generated poster, 10 minutes of telephone follow-up</td>
</tr>
<tr>
<td>Lo et al²⁶ 1996</td>
<td>36 adults (8 type 1) (28 type 2)</td>
<td>Conventional diabetes education program (17 lessons, 4 sessions)</td>
<td>Computer-aided learning (CAL), 16 lessons, 3 to 6 sessions</td>
</tr>
<tr>
<td>McKay et al²⁷ 2001</td>
<td>78 adults (type 2)</td>
<td>Internet information only</td>
<td>On-line tailored “personal coach” to assist in physical activity; personalized feedback</td>
</tr>
<tr>
<td>McMahon et al²⁸ 2005</td>
<td>104 adults (type 2)</td>
<td>Usual care</td>
<td>Web-based care management, messaging system, uploads from monitoring devices</td>
</tr>
<tr>
<td>Nebel et al²⁹ 2004</td>
<td>120 adults (46 type 1) (74 type 2)</td>
<td>Conventional computer-based education program</td>
<td>Adaptive interactive computer-based hypoglycemia education program</td>
</tr>
<tr>
<td>Sheldon⁰ 1996</td>
<td>13 adults (type 1)</td>
<td>Pencil-paper log, daily food intake and activities, no feedback</td>
<td>Daily food intake and exercise recorded by CADET III with feedback and summary</td>
</tr>
<tr>
<td>Smith &amp; Weinert³⁰ 2000 *</td>
<td>30 adults (type 2)</td>
<td>Printed information and education materials</td>
<td>Computerized education and support using electronic communication technology</td>
</tr>
<tr>
<td>Tatti &amp; Lehmann³¹ 2003</td>
<td>24 children (type 1)</td>
<td>Conventional lessons with slides and transparencies</td>
<td>Freeware computer program (AIDA downloadable from internet), an interactive educational diabetes simulator</td>
</tr>
<tr>
<td>Turnin et al³² 1992</td>
<td>105 adults (76 type 1) (29 type 2)</td>
<td>Usual care</td>
<td>Computer-assisted diet education through &quot;Diabeto&quot;</td>
</tr>
<tr>
<td>Wheeler et al³³–³⁵ 1983, 1985</td>
<td>32 adults (type 2)</td>
<td>1 to 2 nutritional education sessions with dietician</td>
<td>Computer-assisted instruction (CAI) videos, nutritional education, meal planning and dietician support</td>
</tr>
<tr>
<td>Wise et al³⁶ 1986</td>
<td>174 adults (86 type 1) (88 type 2)</td>
<td>Usual care</td>
<td>Interactive computer-based knowledge assessment and instruction</td>
</tr>
</tbody>
</table>

* Intervention care did not lead to any significant outcome benefit (p<0.05) when compared with control care.
there was a significant outcome benefit (p<0.05) for the intervention (computer-aided) group compared with the control group at follow-up. The investigators analyzed the articles to assess which interventions led to significant or non-significant results. The investigators grouped the outcomes according to the diabetes self-management education core outcome measures continuum: learning, behavior change, clinical improvement, and improved health status.

RESULTS

Comprehensive literature searches identified 87 articles. The titles and abstracts of these articles were read and 31 articles were determined to be relevant. After reading the full articles, eight additional articles were excluded because there was not a computer-aided diabetes education intervention or health outcomes were not measured. Twenty-three articles representing 19 trials met the eligibility criteria (Table 1). Three computerized approaches were observed in these trials: computerized touch-screen assessment and instruction, computerized assessment with individualized counseling or feedback, and games or simulation.

The total number of patients in the trials was 3167 (2920 adults and 247 children). Adults were subjects in 15 trials and children were subjects in four trials. Five trials focused on insulin dependent diabetes mellitus (IDDM) patients, nine trials focused on non-insulin dependent diabetes mellitus (NIDDM) patients, and five trials involved both IDDM and NIDDM patients. The average trial duration was 7.9 months (range 1 to 24 months).

The evaluated diabetes education content areas included understanding diabetes, self-care & monitoring, prevention & management of complications, emergencies, foot & skin hygiene, regular eye exam, smoking cessation, blood glucose monitoring & recording, urine testing, insulin adjustment & administration, medication, diet & nutrition, food purchasing & meal planning, exercise & physical activity, alcohol, goal setting, problem solving, self-motivation, social support, stress management, social activities, coping, and traveling. There was an average of 4.1 (median of 3) educational content areas per study.

Using the definition for success described in the methods section, significant benefits for the intervention group compared with the control group at follow-up, 16 of 19 trials (84.2%) were successful. Three of the trials were not successful because they failed to show significant beneficial differences between the intervention and control groups on any outcome measure.

One hundred twelve (112) outcomes were measured in the 19 trials. This was an average of 5.9 outcomes per trial. Forty-two percent (42.0%) of the outcomes demonstrated significant improvements (47 of 112 outcomes). Of the types of outcome measures, 10 measured learning (60.0% were significantly improved), 34 measured behavior change (52.9% were significantly improved), 42 measured clinical improvement (38.1% were significantly improved), and 23 measured health status (21.7% were significantly improved). In addition, three measured satisfaction (66.7% were significantly improved).

<table>
<thead>
<tr>
<th>Table 2. Significant outcome measures (p&lt;0.05)</th>
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<tr>
<td><strong>Learning</strong></td>
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<tr>
<td>diabetes knowledge</td>
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<tr>
<td>dietetic knowledge</td>
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<tr>
<td><strong>Behavior Change</strong></td>
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<tr>
<td>fat consumption</td>
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<tr>
<td>calorie consumption</td>
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<tr>
<td>carbohydrate consumption</td>
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<tr>
<td>fruit and vegetable consumption</td>
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<tr>
<td>general dietary behavior</td>
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<tr>
<td>child-parent diabetes communication</td>
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<tr>
<td>computer usage</td>
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<td>self-monitoring activities completed</td>
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<td><strong>Clinical Improvement</strong></td>
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<tr>
<td>weight</td>
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<tr>
<td>cholesterol</td>
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<td>hypoglycemic events</td>
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<td>blood pressure</td>
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<td>hip/waist circumference</td>
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<td>physiologic outcomes</td>
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<tr>
<td><strong>Health Status</strong></td>
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<tr>
<td>school absences</td>
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<tr>
<td>diabetes intrusiveness</td>
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<tr>
<td>diabetes impact</td>
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<tr>
<td>perceived susceptibility to complications</td>
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<tr>
<td>family activities</td>
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<tr>
<td><strong>Satisfaction</strong></td>
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</table>

Thirteen of the trials measured HbA1c. Three of the 13 trials (23.1%) demonstrated a significant improvement in HbA1c levels for the intervention group vs. the control group. Of the remaining trials, five did not demonstrate a

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significant difference, 9, 11, 15-18, 24 three provided within group significance but no analysis for between groups, 19, 20, 26 and the significance level was not calculated for two trials. 25, 30 Other significant outcomes measured in the trials of computer-aided diabetes education are presented in Table 2.

DISCUSSION

In this systematic review, we analyzed computer-aided diabetes education interventions measuring health outcomes evaluated in randomized controlled trials. Sixteen of the 19 trials (84.2%) indicated at least one outcome that was significantly better in the intervention group than in the control group.

An underlying principle of patient education is that knowledge is necessary, but not sufficient, to change health behaviors and improve health status. We observed a steady decrease in the percentage of significantly improved outcomes (from 60.0% to 21.7%), as the outcome measures progressed through the continuum from immediate (learning) to long-term (improved health status).

The cited trials studied a wide variety of interventions generalized into three computerized approaches. Many of the trials also featured interventions with telephone follow-up, educational sessions, feedback, and other resources. Certain types of interventions may be successful whereas others are not. When interventions lead to comparable outcomes, the more feasible or less costly intervention should be selected. Unfortunately, none of the trials in this review provided cost information. Further review of the cited literature is proposed to understand which interventions had significant effects on which outcomes.

Our results indicate that the most common education content areas were diet & nutrition (13 trials), exercise & physical activity (nine trials), blood glucose monitoring & recording (eight trials), and goal setting (eight trials). This is not surprising since these areas are the most important ways to control diabetes. 11 Goal setting and feedback are also important patient centered care activities for the long-term management of diabetes. 32-33

As the prevalence of chronic disease increases and the population of the United States ages, there will be a greater opportunity for computer-aided diabetes education to play a significant role in the future. It is important to know that there have been randomized controlled evaluations that indicate health outcomes improvement.

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REFERENCES


