Abstract

“Health is the vital principle of bliss, and exercise, of health.”
—James Thomson, 18th century Scottish poet

Exercise is considered a crucial component of disease management for individuals with type 2 diabetes, and it is associated with extensive health and mental health benefits. Although the benefits of exercise are well established, most people with diabetes do not engage in physical activity in a regular and sustained manner. To address this, it is important to develop interventions that are easily and broadly accessible and that address specific barriers that prevent individuals with diabetes from participating in physical activity. Several investigations have examined the efficacy of using various forms of technology to deliver or enhance interventions designed to promote regular physical activity. The outcomes have been promising, providing support for continued exploration of telehealth interventions that promote physical activity in the diabetic population. This article provides an overview of telephone, Internet-based, and home-based monitoring interventions that promote physical activity, with a focus on those with diabetes. It also discusses the potential advantages of using telehealth interventions in this context.

Exercise has long been established as fundamental to good health. For individuals with type 2 diabetes, exercise has been identified as an essential component of disease management. Exercise affects the progression and outcome of diabetes, as well as the prevention of other comorbid chronic diseases. Lower A1C, weight loss, and improvement in insulin sensitivity, lipid abnormalities, and blood pressure are all benefits associated with regular exercise for patients with type 2 diabetes. In addition, the act of engaging in regular physical activity can have a catalytic effect on other positive health behaviors such as healthy eating that also contribute to effective diabetes management. Exercise has also been associated with positive effects on mental health outcomes such as decreased anxiety and depression and improved self-esteem and quality of life in individuals with diabetes. For these reasons, the American Diabetes Association (ADA) recommends that individuals with diabetes strive to engage in at least 150 minutes of moderate-intensity activity every week.

Despite the well-known benefits of exercise and the ADA recommendations, most people with diabetes do not exercise on a regular basis, and those who do have high rates of relapse to physical inactivity. One study found that 50% of participants with diabetes dropped out of an exercise program within 3 months, and only 10% were still exercising 1 year later. Because sustained and consistent physical activity is required to maintain health benefits, current evidence suggests that many, perhaps most, patients with type 2 diabetes are not availing themselves of the potential rewards of exercise in the man-
Telehealth interventions vary from the simple use of telephones to automated systems, Internet-based applications, and home-based monitoring systems. Different technologies are used to deliver behavioral interventions, such as telephone (both live and automated systems), Internet-based interventions, and home-based monitoring systems. The sections below provide examples of how each has or may be used to promote exercise for individuals with diabetes.

**Telephone interventions.** One of the greatest advantages of using telephone interventions is the ubiquity of telephones. Although access to computers and the Internet is increasing, telephones, including cellular phones, are widely accessible and affordable to individuals from all socioeconomic and ethnic groups. In addition, most people are highly familiar with and comfortable using telephones.

**Live telephone interventions.** In their most basic format, telephone interventions involve a live provider (e.g., nurse, psychologist, or physician) who either initiates contact with a patient by telephone or who is available by telephone when a patient calls. Interventions typically include some combination of education, goal-setting, problem-solving, and motivational interviewing and have demonstrated effectiveness with various forms of healthy lifestyle change, including smoking cessation, insomnia, and substance abuse. In healthy populations, findings demonstrate that even very brief telephone contact can help healthy adults increase their adherence to physical activity regimens and improve their physical fitness.

Although only a few studies have examined the use of live telephone interventions for exercise promotion in the diabetic population, most have produced favorable results. In a small pilot study, Piette found that veteran patients with comorbid diabetes and depression increased their pedometer step counts during a 6-week intervention that included phone calls from a nurse clinician trained to use cognitive behavioral strategies. In another study involving veterans with comorbid diabetes and post-traumatic stress disorder, researchers examined the impact of an 8-week cognitive-behavioral telephone intervention focusing on diabetes-related self-care practices and delivered by psychology staff. Results revealed significant pre- to post-intervention increases in the self-reported number of days per week that participants engaged in at least 30 minutes of physical activ-
ity. Although these studies produced promising results, they were both limited by small sample size and the lack of a comparison group.

Trained nonprofessionals have also proven effective in the delivery of these interventions. In a very small study, Batik et al. found that participants responded favorably to motivational and supportive telephone calls by older volunteers, with a trend toward improved physical activity. In another study conducted by Sacco et al., college students trained as diabetes coaches conducted brief phone calls designed to promote adherence to a diabetes self-care regimen. Participants in this study reported an increase in exercise participation.

Overall, telephone calls delivered by either health care professionals or lay people have demonstrated some efficacy in promoting physical activity in both nondiabetic and diabetic populations. Even very brief calls appear to produce favorable results. However, because there is great variation in the methods used, frequency and length of phone calls, training of the callers, focus and content of the calls, and measures used to record physical activity, it has been difficult to determine which components of the telephone interventions produce the most positive effects. More methodologically sound research is needed to clarify these findings.

Automated voice-response telephone interventions. Recently, this promising line of investigation has taken the next technological step: using automated interactive voice-response telephone technology to provide behavioral health interventions. These computer-controlled telephone programs allow for fully automated voice-response interactions between individuals and the computer system, delivering interventions that are similar to those described above (i.e., education, feedback, problem-solving, and so forth).

Notable strengths of these systems include the possibility of automated outbound telephone calls, which eliminate reliance on user motivation to initiate the call, and voice-recognition technology, which allows users to speak their responses into the telephone rather than use their touch-tone keypad. Both of these advances facilitate participant use of the system by making interventions more user-friendly and providing a closer approximation to human interpersonal interaction. In fact, Friedman et al. have shown that compliance rates with an outbound phone call system that promoted physical activity in healthy adults increased dramatically when compared to a system that relied on incoming calls. Furthermore, these automated systems can be tailored to incorporate individual participant characteristics and prior responses into intervention content.

These automated telephone systems have produced promising findings. Although users do not actually speak with a live person, participants report a favorable reaction to the “person” recorded on the system, including positive feelings and emotional responses such as guilt or love. Additional advantages of an automated phone system over a live person include increased flexibility (e.g., calls at any time of day or night and the convenience of being treated at home) and reduced demand characteristics. Individuals may respond more honestly about their behavior or adherence with goals to an automated system than to a live person. Finally, responses to automated systems have been shown to be valid and reliable.

Automated phone systems show great promise as a method of delivering interventions designed to affect behavior change, and particularly to promote physical activity. For example, interactive voice-response systems that provide feedback and behavioral suggestions through regular, brief contacts have been successful in promoting adherence to exercise regimens in a nondiabetic population. However, little is known about how this type of system could work to promote physical activity in a diabetic population. Clearly, it is an area that is ripe for further investigation.

Internet-based interventions
As access to computer technology has grown, the Internet has become a promising vehicle for the delivery of health information and behavior-change interventions. In a recent review of eHealth interventions, Norman et al. found support for the use of Internet-based interventions in increasing levels of physical activity. Effect sizes for Internet-based interventions were comparable to non-Internet-based interventions, but the authors concluded that the broad reach and potential for cost-effectiveness of Internet interventions gave them an advantage. Because the components of the interventions,
study lengths, comparison groups, and target populations varied widely among the studies reviewed, it is difficult to make direct comparisons.

Little research has been done on Internet-based interventions to promote physical activity in diabetic populations. However, a team of researchers \(^46,47\) studied the impact of a personalized, interactive self-management Internet site called Diabetes Network (D-Net) in patients with type 2 diabetes. McKay et al. \(^47\) compared D-Net, which involved a personalized physical activity plan and access to an online personal coach, to an Internet information-only condition. No significant differences were found between the two conditions; participants in both groups significantly increased their levels of moderate and vigorous physical activity. Interestingly, however, the D-Net condition resulted in a small, nonsignificant decrease in depressive symptomatology compared to a trend for increased depressive symptoms in the information-only group.

Glasgow et al. \(^46\) extended the findings of McKay et al. \(^47\) by examining the benefits of adding tailored self-management training or a peer support component to D-Net. Results did not demonstrate any significant increases in physical activity or significant differences between treatment conditions. Usage was greatest, however, among participants in the peer support condition, supporting the belief that human interaction is an important component. \(^35\)

In both studies, Internet site use declined over the course of the interventions. Future research should focus on efforts to retain participants in these Internet-based interventions because those who sustain involvement reap the greatest rewards. \(^46,47\)

Computerized technology has also been used to deliver and evaluate the relative efficacy of two goal-setting strategies to promote physical activity among people with diabetes. Richardson et al. \(^48\) compared the use of lifestyle goals, which encourage participants to increase their daily accumulated step counts (hence encouraging any activity that involves movement), to the use of structured goals, which require participants to increase their bouts of activity (i.e., walking that lasts \(\geq 10\) minutes at a pace of \(\geq 60\) steps per minute). All participants wore pedometers equipped with USB ports to upload step-count data to an Internet site and received automated step-count feedback, automatically calculated goals, and tailored motivational messages. Both methods of goal-setting resulted in increased physical activity. However, participants in the lifestyle-goals group had greater adherence to the intervention and reported higher levels of satisfaction.

This study highlights the effectiveness of using computer technology as a medium to assess and deliver physical activity interventions. Furthermore, using computer technology in this way allows for immediate feedback about physical activity levels, which has been shown to be reinforcing. \(^49\)

The potential of Internet-based and technological interventions seems limitless. As third-generation technologies continue to advance and become a greater part of everyday life, researchers can take advantage of the popularity of computerized devices to continually interface with their participants. Sophisticated data collection tools and interactive technology may enhance ecological validity and convenience for participants, thus improving adherence to the intervention and study-related outcomes. For example, Kim et al. \(^50\) collected blood glucose readings and physical activity measurements using a pedometer and glucose meter attached to participants’ cell phones. The resulting data were uploaded to a study Internet site and augmented by participants’ direct entry of food intake and activity levels. Using all of these data, the Internet system generated clinical recommendations sent via text message to participants’ phones. Although changes in physical activity level were not reported as a primary outcome, this study demonstrates the capabilities available for further exploration.

Overall, more research is needed to provide an accurate assessment of the efficacy of Internet-based or computerized interventions in increasing physical activity in the diabetic population. Because many interventions include numerous components, it can be difficult to discern the “active ingredients” associated with successful behavior change. Additionally, evidence suggests that once the novelty wears off, participants are less likely to continue to use computer-based interventions that require user-initiated action. \(^46,47\)

Finding methods to help participants maintain interest may be a crucial component of enhancing the effectiveness of Internet-based interventions. Suggested strategies include regularly updating the Internet site with new information and education, including interactive components such as physical activity logs that enable participants to track their progress; use of third-generation technologies (e.g., text messaging); continued social support through personalized feedback from a live person; and proactive contact in the form of outgoing e-mail prompts rather than reliance on user-initiated contact. \(^34,42,45,51\)

**Home-based monitoring interventions**

Monitoring systems that relay medical information from a patient’s home to a health care setting have become more sophisticated and easier to use during the past few decades. In the late 1980s, the first home monitoring devices became available. They were simple patient alarms that elderly or house-bound patients were encouraged to wear and could activate if they had fallen or were in danger. The target population for most home-based monitoring devices continues to be the elderly, a population that is less likely to be comfortable using computer-based technology.

Although the technology underlying these devices may be sophisticated, the interface with the patient is usually very simple and designed to be highly user-friendly (e.g., requiring the use of just a few buttons). It is now possible for patients to wear wireless devices that monitor objective medical information such as heart rate,
blood pressure, and blood glucose levels. In addition, subjective information (e.g., “How are you feeling today?”) can be assessed in patient homes and then transmitted to health care professionals.

Most home-based monitoring interventions involve a combination of live interactions with providers and technology to monitor and transmit patients’ health variables. Providers receive and evaluate the information from patients and then provide appropriate feedback and advice remotely, usually by telephone. These devices are particularly helpful in rural settings or in cases in which patients have difficulty attending clinic appointments because of disability because they allow health care providers to gather information and monitor it regularly without requiring a face-to-face visit.

The potential benefits of home medical monitoring devices are numerous: elderly patients who require frequent monitoring can remain in their homes, unnecessary travel can be avoided, the frequency and duration of hospital stays can be reduced through early intervention, clinics can allocate resources effectively, and appropriate personnel can be alerted when a medical event takes place.

One recent study examined the use of a tool called Health Buddy to promote exercise for physically inactive veterans. Health Buddy is a simple device that plugs into a telephone landline and allows patients to respond to questions by pushing one of four large buttons. The investigators found that the Health Buddy intervention was comparable to a telephone intervention in that both were associated with low rates of adverse events. Importantly, although exercise adherence declined for both groups during the 8-week intervention, the adherence rate was significantly higher for the Health Buddy group.

Additional studies evaluating the feasibility, satisfaction, and utility of home medical monitoring devices to help patients manage their medical conditions are scarce but promising. Patients have exhibited positive outcomes and reported positive reactions (e.g., found the devices user-friendly and useful) to devices that range from simple tools that use basic telephone technology to sophisticated devices that transmit more complex medical information.

Home medical monitoring devices have great potential for use with individuals who have diabetes who are interested in participating in home-based activity programs. Although physical activity is often prescribed as part of a diabetic treatment plan, the fear of medical destabilization has been identified as a significant barrier to patients’ adherence with this recommendation. Remote medical monitoring could provide some patients with the assurance necessary to allow them to engage in physical activity on their own. For example, individuals with diabetes may feel more comfortable engaging in physical activity if they know that important objective measures of their health (e.g., blood glucose values) are being monitored by health care professionals. Although there is no known research that has used these devices specifically to promote physical activity for patients with diabetes, this approach would likely enhance adherence to exercise prescriptions.

Considerations and Future Directions
The use of telehealth applications to promote physical activity in individuals with diabetes shows great promise but is still in its infancy. Many telehealth interventions that promote physical activity have been shown to be comparable to in-person interventions, while also offering several advantages.

To date, automated telephone interventions have shown the greatest promise, with the significant advantage of being a widely accessible and comfortable form of technology. The results associated with Internet interventions have been somewhat inconclusive, although there are some clear advantages to using this technology. For example, online support communities can be accessed at any time, the Internet can offer extensive health information that can be individually targeted, and feedback can be provided in visually appealing formats (e.g., exercise or weight charts). Furthermore, younger adults are often very comfortable with Internet-based technology, and it is becoming increasingly accessible to older adults. Home-based monitoring systems have been successfully used to monitor medical variables, especially with older adults, and emerging evidence suggests that they may be useful in promoting exercise. The monitoring aspect of the systems has the potential to offer significant advantages for individuals with diabetes who are interested in participating in a home-based exercise program.

Telehealth interventions that promote physical activity for individuals with diabetes have produced promising findings that support the need for further investigation. The sections below outline some of the advantages of using telehealth interventions to promote physical activity in the diabetic population.

Potential cost-effectiveness
One significant advantage of using telehealth interventions to promote physical activity is their potential cost-effectiveness. For example, although automated telephone systems can be costly to develop and set up, there is only a small incremental cost for each additional user, and the intervention can be widely distributed from a single call center. Updating systems based on new developments can often be done with minimal cost.

Compared to traditional clinic-based physical activity promotion programs, telehealth interventions may be viewed favorably with respect to 1) the cost and effort of recruiting and training professional personnel, 2) the need for appropriate physical facilities, and 3) the burden on patients to attend regular sessions outside their homes in the face of competing life priorities, especially for low-socioeconomic populations. Furthermore, clinic-based exercise programs or staff with behavioral expertise are often not available to patients with diabetes. When they are available, it is often the small subpopulation of highly motivated patients who receive an intervention at a high cost per patient. At least one study has been able to
Table 1. Empirical Studies Examining Telehealth Interventions Promoting Physical Activity in Patients With Diabetes

<table>
<thead>
<tr>
<th>Citation</th>
<th>Sample Size and Target Population</th>
<th>Intervention Delivery</th>
<th>Control Group and Random Assignment</th>
<th>Length of Intervention</th>
<th>Physical Activity Measurement</th>
<th>Primary Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batik et al., 2008</td>
<td>( n = 14 ), Older adults (&gt; 64 years), diabetes</td>
<td>Ongoing telephone support delivered by older adult trained volunteers</td>
<td>Control group: waitlist Random assignment: yes</td>
<td>6 months minimum</td>
<td>Self-report measured by questionnaire</td>
<td>Nonsignificant increase in percentage of participants sufficiently active</td>
</tr>
<tr>
<td>Collins et al., 2009</td>
<td>( n = 20 ), Type 2 diabetes and comorbid post-traumatic stress disorder</td>
<td>Weekly calls delivered by trained psychology staff</td>
<td>Control group: none</td>
<td>8 weeks</td>
<td>Self-report measured by questionnaire</td>
<td>Significant increase in self-reported number of days/week physically active</td>
</tr>
<tr>
<td>Piette, 2005</td>
<td>( n = 11 ), Diabetes and comorbid depression</td>
<td>Weekly calls delivered by nurse clinician trained with cognitive behavioral therapy skills</td>
<td>Control group: none</td>
<td>12 weeks</td>
<td>Pedometer and step count log</td>
<td>Significant increase in step counts</td>
</tr>
<tr>
<td>Sacco et al., 2009</td>
<td>( n = 62 ), Type 2 diabetes</td>
<td>Weekly calls for 3 months and then biweekly calls for 3 months delivered by paraprofessionals</td>
<td>Control group: treatment as usual Random assignment: yes</td>
<td>6 months</td>
<td>Self-report measured by questionnaire</td>
<td>Significant increase in self-reported adherence to exercise goals</td>
</tr>
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</table>

**Internet-Based Interventions**

<table>
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<th>Primary Outcome</th>
</tr>
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<tbody>
<tr>
<td>Glasgow et al., 2003</td>
<td>( n = 320 ), Type 2 diabetes</td>
<td>Information-based self-management Internet site with either tailored self-management training or peer support components</td>
<td>Control group: access to information-based self-management Internet site only Random assignment: yes</td>
<td>10 months</td>
<td>Self-report measured by questionnaire</td>
<td>No change in physical activity levels across groups</td>
</tr>
<tr>
<td>McKay et al., 2001</td>
<td>( n = 78 ), Sedentary, type 2 diabetes</td>
<td>1) Information plus graphic feedback comparing baseline activity level to guidelines plus information, 2) personalized physical activity plan, 3) support from personalized coach, 4) peer support groups and live chat</td>
<td>Control group: access to information plus graphic feedback with no active intervention Random assignment: yes</td>
<td>8 weeks</td>
<td>Behavioral Risk Factor Surveillance System</td>
<td>Significant increase in step counts for both groups; no significant difference between groups</td>
</tr>
</tbody>
</table>

*continued on p. 133*
demonstrate the cost-effectiveness of an automated telephone self-management support system in providing care for individuals with diabetes. Although it is often speculated that telehealth programs are cost-effective, only a few studies have actually conducted cost analyses. Further cost analyses should be performed to better understand the costs associated with the development and implementation of these types of interventions and their impact on health care utilization costs.

Enhancing home-based physical activity programs
The utility of telehealth services for physical activity promotion is supported by findings that suggest exercise adherence is greater for individuals who participate in exercise programs on their own (home-based programs), rather than in structured group-based programs.61,62 Making telehealth services that promote physical activity available in a home environment with interventions that are individually tailored can also make them more accessible to a broad spectrum of the community.

Addressing barriers to physical activity in the diabetic population
Studies have shown that people with chronic illnesses are less likely to engage in either moderate or vigorous activity and are more likely to stop exercising once they have started.4 Thus, it is important to consider health- and disease-specific barriers to exercise (e.g., health and safety concerns) and the different motivating factors (e.g., disease management) when devising an exercise intervention for those with medical issues.

Barriers that are specific to individuals with diabetes include their increased risk of hypoglycemia, foot sores during exercise, pain, feeling sick, and the need to monitor blood glucose before and after exercising. As a result of these health issues, individuals with diabetes may be particularly responsive to telehealth interventions to promote exercise because their illness-related barriers may make it more difficult for them to travel to appointments.

To maximize the effectiveness of a telehealth intervention for people with diabetes, the special needs of this population need to be taken into account when developing a protocol to promote and maintain physical activity. Furthermore, using the monitoring capabilities of telehealth interventions can potentially facilitate a greater sense of safety for those who fear that engaging in physical activity will trigger a medical event.

Enhancing accessibility
A significant advantage of using telehealth interventions as health-promotion tools is the potential for enhancing the accessibility of these important services. The vast majority of individuals living in the United States and most developed countries have access to telephones, and computer and Internet access is continuously expanding and has become almost essential for younger adult populations. Using these technologies to provide health information, support, and motivation and to measure and monitor health variables and behavior is an innovative way to deliver care and promote physical activity.

Limitations of Telehealth Interventions
Although there are many potential advantages to using telehealth methods to promote physical activity, there remain several barriers that prevent some from using telehealth interventions. Although telephone technology is omnipresent and much of our population has access to a telephone, there is still a segment of the population that does not have easy or inexpensive access to a telephone. For example, individuals living in nursing homes or other structured living environments often have shared phones or do not have private spaces for conversations. Telephone interventions are often not ideal for those with hearing impairments and for patients who have a strong preference for in-person communication. Internet-based interventions can be appealing to individuals who are comfortable with computers, but can be intimidating to those who are not comfortable with this technology.

In addition, although computer use is on the rise, a substantial proportion of the population does not have easy or private access to a computer or access to the Internet. This is particularly true of those from older generations and with fewer financial resources. And finally, people can be

| Table 1. Empirical Studies Examining Telehealth Interventions Promoting Physical Activity in Patients With Diabetes, continued from p. 132 |
|---|---|---|---|---|---|---|
| Kim et al., 2007 | $n = 71$, Type 2 diabetes | Text messaging delivered to phone; access to Internet site with diabetes information | Control group: usual care with glucose meters | Random assignment: yes | 12 weeks | Pedometer data | Not reported |
| Richardson et al., 2007 | $n = 35$, Sedentary, type 2 diabetes | Internet-based system with pedometers embedded with USB ports | Comparison group: received pedometer with different feedback about step counts | Random assignment: yes | 6 weeks | Pedometer data | Significant increase in step counts for both groups; no significant difference between groups |

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similarly intimidated by home-based monitoring programs, and there is a significant cost associated with setting up such systems. Clearly, telehealth interventions should be viewed as a method of enhancing clinical services. It is unlikely that they will ever replace face-to-face contact or fully replicate some of the advantages of in-person meetings.

Although the potential applications of telehealth to promote physical activity in the diabetic population seem limitless, it will be important to thoroughly and systematically investigate the components of these interventions to understand what works most effectively and with whom. Many of the studies that have been conducted to date have had small sample sizes and widely varying methodologies and have lacked proper control groups. See Table 1 for an overview. Well-designed studies are needed to help identify the components of telehealth interventions that are responsible for positive outcomes.

In addition, it will be important to determine the user characteristics that are associated with favorable responses to the range of different telehealth interventions. Given the innovative and nontraditional nature of these interventions, some individuals may be reluctant to use these treatment options. However, as their effectiveness is demonstrated and if intervention development is guided by the needs and responses of the diabetic patient population, they have the potential to become a desirable means of enhancing diabetes treatment management and physical activity promotion.

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32Medical Information Systems Unit Team: Data on call schedule adherence from trials of two automated phone systems to increase physical activity. Boston, Mass., Boston University Medical Campus, 2003


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