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ABSTRACT

This study examined whether video games could be effective health education and therapeutic interventions for children and adolescents with diabetes. KIDZ Health Software developed a game about diabetes self-management, and tested its effectiveness for children with diabetes. The Packy and Marlon Super Nintendo video game promotes fun, self-esteem, social support, increased knowledge, positive health behaviors, and positive health outcomes, and it teaches diabetes self-management skills. The characters are adolescent diabetic elephants going to a diabetes summer camp. Players help the characters monitor blood glucose, take appropriate amounts of insulin, review diabetes logbooks, and find foods according to the right number of food exchanges. Players learn about self-care and typical social situations related to diabetes. To win, players must engage in specific health-promoting behaviors. Children with diabetes and their parents from two clinics participated in a study that involved interviews before and after routine visits, testing of glycated hemoglobin, and receipt of either Packy and Marlon or a pinball video game to take home and play. After 6 months, participants rated the games. Interviewers examined time spent playing the game, self-efficacy, social support, knowledge, and self-care. Results indicated that children not only liked Packy and Marlon as well as the pinball game, but Packy and Marlon also significantly improved self-care behaviors, self-efficacy, and health outcomes. (Contains 1 table, 9 figures, and 29 references.) (SM)

Health Education Video Games for Children and Adolescents: Theory, Design, and Research Findings

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Interactive video games offer unique advantages over conventional methods of health education. Although pamphlets, videos, or health education classes can provide a great deal of didactic content, a compelling video game can expose players to essential content over and over again. Young people will typically play a game they like for several months, repeatedly trying to complete the same game levels so they can progress further in the sequence. Video games provide opportunities to rehearse new skills in a realistic and interactive environment and allow players to see the consequences of every choice they have made. Video games are especially motivating if they include appealing stories and characters, compelling challenges, and immediate feedback, so that players learn by making decisions and seeing the outcomes. No other form of mediated or face-to-face health education offers this combination of interactivity, entertainment, challenge, decision-making, feedback, repetition, duration, and privacy.

The widespread appeal of video game playing, along with its use of interactivity to involve players in challenging situations, creates a unique opportunity to reach young people with health messages. Children are already motivated to play video games and many say they prefer them for learning instead of other print or video media. In individual interviews, 30 children typically mentioned that they preferred controlling the action and learning by doing in the context of video games (Lieberman & Brown, 1995).

- "In a video game you can do what you want to do." (Boy, age 11)
- "I can control a video game like it's my real self." (Girl, age 8)
- "A video game is fun because it lets you try things out." (Girl, age 6)

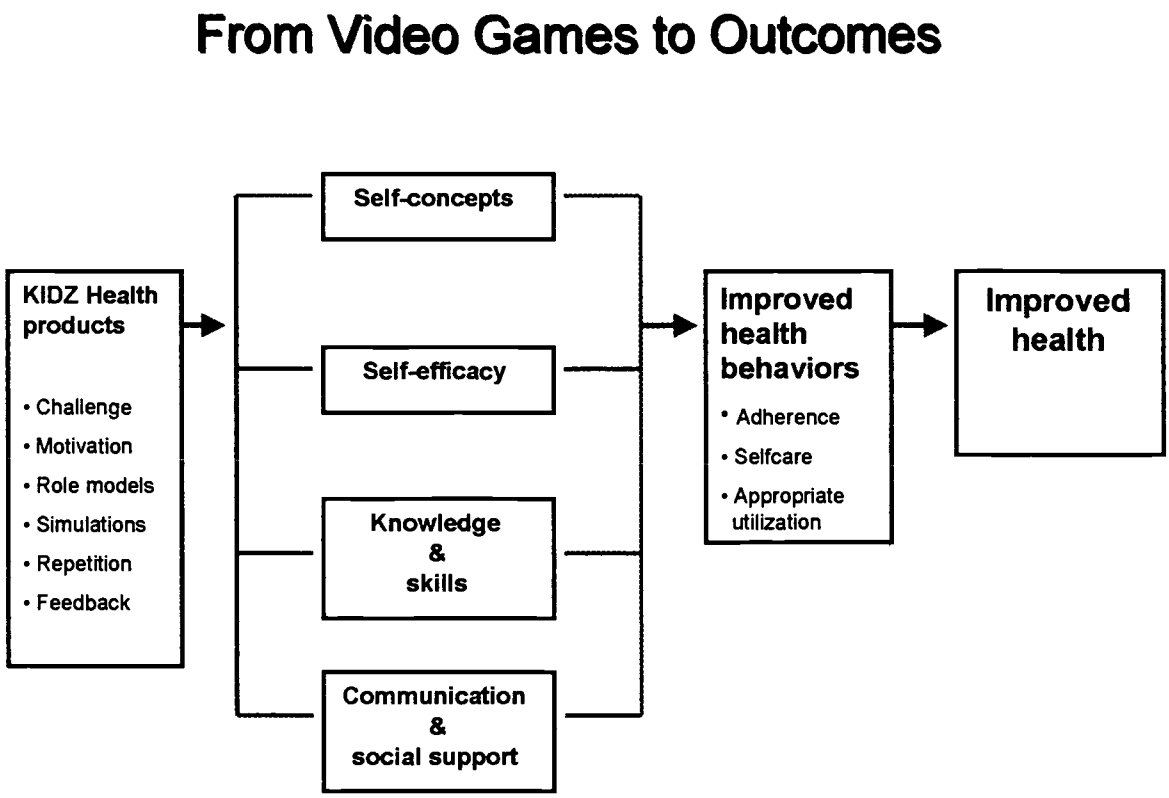
In the US, children and adolescents play video games avidly during leisure time. Video game playing is a very popular pastime for young people in all socio-economic groups and is also highly accessible. The hardware is portable, costs much less than computers, and plugs into a color TV set. More than 70 percent of homes with children have video game systems; children who play video games spend an average of 1.5 hours playing each day (Randolph, 1997).

Video games have interactive capabilities that lend themselves well to experiential learning—and games can be particularly effective when they incorporate well-established instructional design principles. This paper discusses the theoretical basis of KIDZ Health video game design. It also presents the design of a video game focusing on diabetes self-management and reports findings from a randomized controlled experiment testing the effectiveness of the video game for young people who have this chronic condition.

Game Design Based on Theory and Research

A theory-based model presents the goals of KIDZ Health video games, including their potential effects on mediating factors that can influence health behaviors and outcomes (See Figure 1). The model is illustrative, and is not intended for path analysis. It illustrates interrelationships among the emotional, social, cognitive, behavioral, and physiological outcomes expected with KIDZ Health games. Arrows indicate the hypothesized direction of influence and show that video game playing is expected to enhance self-concepts, self-efficacy, knowledge and skills, and communication and social support, mediating factors that can, in turn, lead to improved health behaviors and health outcomes.

Figure 1:



The appeal of playing a video game

Video games must be fun if children are going to play them during leisure time. The success of failure of this kind of health intervention depends in great part on the appeal of the activity itself. To be challenging and fun, video games should encourage players to participate in the adventure and should respond immediately to players' input. In experiments to determine what makes video games fun for children, it was found that children like games that provide challenge to reach a goal, stimulation of curiosity, control over the action, and fantasy themes (Malone & Lepper, 1987). These features have been incorporated into the design of KIDZ Health video games.

Self-concepts

KIDZ Health video games are action/adventure games with main characters who help others prevent a health problem (e.g., AIDS), treat the damage caused by a health problem (e.g., smoking), or manage their own chronic condition (e.g., asthma, diabetes) while they engage in compelling adventures. Young players assume the role of a character and, in a simulation, make health decisions for that character and see the consequences.

Some children who have a chronic health condition such as asthma or diabetes suffer from low self-esteem. To help raise their self-esteem, KIDZ Health video games feature attractive and efficacious characters who also have the chronic condition. Previous research has found that children are highly attentive to characters who are very similar to them and they feel validated to see those characters represented in mass media (Johnston & Ettema, 1986; McDermott & Greenberg, 1985).

Interactive games that respond to the player's input and are not too easy or too difficult can boost self-esteem (Clements, 1987; Krendl & Lieberman, 1988). As players become successful they perceive themselves as skillful and are likely to gain self-esteem (Niemiec & Walberg, 1987). Effective games provide an environment in which players can experiment, fail, learn, and ultimately succeed. KIDZ Health video games offer challenges that are difficult but achievable for target users ages 8 to 14. Extensive user testing helped set the optimal level of difficulty—to make sure the games were not too easy or too difficult to win.

Social Support

For young people video game playing is often a social activity, as is talking about games even when they are not in use (Clements, 1985; Salomon & Gardner, 1986). Children often help each other with game strategies and enjoy games they can play with others (Lieberman, 1985; Malone & Lepper, 1987). Video games about health topics can give children new roles in the family because, typically, they know much more than their parents know about action video games. Here is a world in which children are the experts.

A health-oriented video game has the potential to stimulate discussion with friends, family, and clinicians about a health issue; help children talk about their own condition with others when they otherwise might try to hide it; and encourage them to seek support and advice. To facilitate social

interaction and discussion about health and selfcare, KIDZ Health games offer a two-player option in which players must work cooperatively to win the game.

Knowledge

Hundreds of research studies on the educational effectiveness of computer-based instruction show that well-designed interactive media can teach children effectively (see Kulik & Kulik, 1991; McNeil & Nelson, 1991; Salomon & Gardner, 1986). This is especially true when learners proceed at their own ability level and pace, receive individualized performance feedback, and review material until they understand it thoroughly (Kozma, 1991). These features are inherent in action-oriented video games, which progress from easy to difficult levels of game play, respond immediately to the player's input, and offer unlimited opportunities to rehearse and retry.

Computer game formats have been effective in motivating reluctant learners and in attracting them to subjects they would ordinarily avoid (Lepper & Gurtner, 1989). The motivational appeal of interactive media is especially useful in reaching the young people who do not seek information or advice about their own health or how to manage chronic conditions (Deardorff, 1986; Gustafson et al., 1987).

Health behaviors

Knowledge about health and selfcare is generally not highly correlated with appropriate health behaviors (Maibach, Flora, & Nass, 1991); knowing is not the same as doing. For instance, most smokers already know the dangers of smoking yet many do not quit. Adolescents are an especially difficult group to reach with health behavior-change messages. They typically feel that they are not vulnerable even if they are aware of the health risks of their current behavior (Chaffee & Roser, 1986).

Three mediating factors have been shown to improve the link between health knowledge and health behavior, and video games can be designed to improve these factors. The first is *involvement*. When people believe a topic is important to them their involvement in that topic is high. Those with high involvement are more motivated to acquire information about that topic, they pay greater attention to information about it, and they are more likely to behave in accordance with that information (Chaffee & Roser, 1986). To increase children's involvement in a health

issue, video games can demonstrate the positive outcomes that come from good prevention and selfcare. Video games can provide them with opportunities to learn about a health topic just at the time when their involvement in that topic has been increased.

Second, the individual should *believe that changes in health behaviors will actually lead to positive outcomes* (Ewart et al., 1983). Video games can show players the positive outcomes that characters experience as a result of proper prevention and selfcare, and this can help increase young people's beliefs that behavior can indeed affect health and well-being.

A third factor that strengthens the correlation between knowledge and behavior is *self-efficacy*, the belief that one is capable of carrying out a desirable behavior. Self-efficacy consists of beliefs about how well one can bring about desirable events and avoid undesirable ones (Bandura, 1982; 1986). People who have a strong sense of self-efficacy regarding health and selfcare are more likely to have a healthy lifestyle, seek and follow medical advice when ill, avoid life crises, cope with crises that do occur, and establish closer social ties so that social support is available to buffer against illness (Grossman, Brink, & Hauser, 1987; Peterson & Stunkard, 1989). Conversely, those with low health self-efficacy believe they are helpless and therefore are more likely to become ill and to cope ineffectively with medical problems. Studies have shown that increases in health self-efficacy lead to improvements in health behaviors and outcomes (Maibach, Flora, & Nass, 1991). When people learn new information and believe they are efficacious enough to apply it successfully, they are more likely to try and succeed. Video games can potentially improve self-efficacy when players rehearse behaviors in a simulated environment and then experience successful consequences as a result of their own decisions.

Health outcomes

If a health education intervention can improve health behaviors, then improved health outcomes should ensue. Several studies have demonstrated a correlation between health education and improved health behaviors and outcomes (Deardorff, 1986; Lorig et al., 1985; Paperny, 1991; Robinson, 1985). People who learn selfcare methods have fewer medical problems that require a physician's attention, on average, than those who are not taught selfcare methods. One study found that self-caring individuals who had received health education spent 26 percent less on hospital bills and 19 percent less on physician services than those who did not engage in appropriate selfcare (Ferguson, 1989).

Diabetes Video Game

Packy & Marlon is a Super Nintendo video game designed to teach diabetes self-management skills to children with diabetes, ages 8 to 14. The characters in *Packy & Marlon* are two adolescent elephant friends who have diabetes and are on their way to a diabetes summer camp. The player takes the role of Packy in a one-player game and Marlon is added when a second player joins in. The characters must save their camp from rats and mice who have scattered the camp's food and diabetes supplies. Players also must help their character monitor blood glucose, take appropriate amounts of insulin, review a diabetes logbook, and find foods containing the right number of food exchanges (bread, fruit, meat, milk, vegetable, and fat) according to the meal plan for each meal and snack. Players also learn about selfcare and typical social situations related to diabetes by answering multiple-choice questions posed by camp counselors throughout the game. The 24 levels of play take place in the camp's forests, playgrounds, rivers, mountains, haunted houses, and lakes, with each level becoming increasingly difficult to complete.

There are six game levels in a day, four days in all. Each game level involves a meal or snack: breakfast, morning snack, lunch, afternoon snack, dinner, and bedtime snack. Players see a menu at the beginning of each level and must help their character find and eat the foods in that meal plan—or substitute equivalent food exchanges—to keep blood glucose in the normal range. Players can press a button to look at a food exchange calculator that identifies the exchanges in all foods included in the game, such as a bowl of cereal or a tuna sandwich. They can press the button again to see a logbook of their character's prior blood glucose test results, insulin injections, and food exchanges consumed.

Packy & Marlon models game challenges after diabetes challenges. Children with diabetes, like the protagonists in *Packy & Marlon*, must avoid certain threats to their well being and must engage in particular activities repeatedly. To win, players must learn how to engage in specific behaviors that will help their character stay healthy. Repetition of these features is a key ingredient. A well-designed video game is never the same experience twice; for that reason children are likely to return to it over and over again. This repetitive play exposes players to the same content and enables the same rehearsal of skills dozens of times over the course of several months.

Controlled Field Experiment

With funding from the National Institutes of Health, we conducted an outcome study to test the impact of *Packy & Marlon*. The study was a controlled field experiment in which young people with diabetes were randomly assigned to take home the diabetes education video game or an entertainment video game with no health content. Study participants were recruited from the Stanford University Medical Center and a clinic of Kaiser Permanente in San Jose, California. Those eligible for the study were between the ages of 8 and 16 years, were diagnosed with insulin-dependent diabetes at least three months previously, and were patients of pediatric endocrinologists at the two clinic sites.

Participating children and parents agreed to be interviewed at the clinic just before the next routine clinic visit and before the following two routine clinic visits, which occur every three months. They also agreed that the child's next three HbA1c (glycated hemoglobin) blood test results, taken at three-month intervals, could be shared with the researchers. At the first meeting, the child was interviewed for about 20 minutes and a parent filled out a paper-and-pencil questionnaire in a separate room. Then the child was randomly assigned either to the treatment group or the control group, with stratification by gender and clinic site to assure an equal division of boys, girls, Stanford patients, and Kaiser Permanente patients in each of the two groups.

Also at the first meeting, a researcher gave the child a *Super Nintendo* video game system to take home. If assigned to the treatment group, the child received a video game cartridge of *Packy & Marlon*, and if assigned to the control group the child received a pinball entertainment video game cartridge. All study participants were told they could play their game at home, or anywhere else, as much or as little as they wished. They were also instructed to follow any rules in their household regarding video game playing, including limitations on amount of time spent with video games, or the time of day video games were allowed.

Measures

To evaluate enjoyment of the game, participants were asked after six months to rate their game on a four-point scale ranging from "Don't like to play it at all" to "Like to play it a lot." Amount of time spent playing the game was determined by asking children a series of questions about the number of times they played the video game alone and with others during the past three

months, and they also estimated how much time they usually spent playing in one session. Total amount of time spent playing the game was calculated from these responses.

Perceived self-efficacy was measured at baseline, at three months, and at six months using a widely used and validated procedure (Bandura, 1986) consisting of questions beginning with, "How hard or easy do you think it would be for you to...?" The child was shown a Likert scale from 1 to 7, with "1" labeled "Very hard" and "7" labeled "Very easy," and was asked to assign a number from 1 to 7 in answer to each question. Eleven self-efficacy questions were used, including self-assessments of how hard or easy the child thought it would be for them to eat the right foods, to keep blood sugar under control, to keep a diabetes logbook, to remember to take all insulin shots every day, to test their own blood sugar, to remember their diabetes supplies when leaving the house, to take care of a diabetes emergency, and to talk with their friends about diabetes, among other items. The eleven responses were averaged to form one self-efficacy score.

Social support was measured by asking the parent to recall how many times during the past month their child initiated a discussion about their diabetes care and initiated a discussion about their feelings related to having diabetes. The two responses were summed.

Knowledge about diabetes was tested during the child interviews, which included questions about food exchanges, blood glucose monitoring, diabetes causes and symptoms, and appropriate selfcare; all items in the knowledge scale asked for information that had been presented at various points in the video game. Correct answers to the knowledge items were summed to form one knowledge score.

Diabetes selfcare consisted of parents' responses to five items, all measured in 7-point scales. They rated their child's motivation to manage diabetes (such as, test blood sugar, take insulin, cooperate with parents and doctor, and eat the right foods), with "1" being "Not motivated" and "7" being "Highly motivated". Other questions included: "How poorly or well does your child manage diabetes for his or her age?" (with "1" being "Very poorly" and "7" being "Very well"); "When you are with your child and he or she wants to eat, how often is it necessary for you to give your child advice about the right foods to eat?" (reverse coded), with "1" being "Never," "4" being "Half of the time," and "7" being "Always" (for this and the remaining items), "As far as you can see, how often does your child independently choose the right foods to eat to keep blood sugar under control?"; and "How often does your child independently remember to take diabetes supplies along when leaving the house?"

The two clinics provided HbA1c blood test results. Urgent care visits were measured by asking the parents to recall their child's total number of unscheduled doctor visits for problems related to diabetes during the past three months, including urgent care and emergency room visits.

Data analysis

This study examined the average gain scores in the two experimental groups to determine the difference between baseline measures and those at the conclusion of the data collection six months later. To create gain scores, baseline measures were subtracted from the six-month measures. Gain scores control for initial differences in measurement, and this is especially important because HbA1c tests had slightly different reference ranges at the two clinic sites. We conducted two-tailed, unpaired t-tests to compare the gain scores of the treatment group and the control group.

Results

Children in the treatment group enjoyed playing *Packy & Marlon* as much as the control group liked playing the pinball game. Six months after receiving their game, 68 percent of treatment group members said they "like" the video game or "like it a lot," while 61 percent of the children in the control group responded this way. On average, participants who received the *Packy & Marlon* game reported playing it 34 hours during the six months of the study; they averaged 18 hours during the first three months and 16 hours during the second three months. The control group yielded similar results and there was no statistical difference between the treatment and control groups in their average amount of time spent playing their game. Ninety percent of the treatment group reported playing the game for at least two hours during the first 3 months.

Table 1 presents the baseline and six-month results and gain scores (change) of the main measures in this study. Included are the results of the t-tests comparing gain scores of the treatment and control groups, reported as specific p values.

Table 1: Study findings and unpaired t-tests (2-tailed significance)

Measure (source)	Treatment group (n=31) mean (SD)			Control group (n=28) mean (SD)			
	Baseline	6 months	Change	Baseline	6 months	Change	p value
Self-concepts Self-efficacy ratings for diabetes selfcare (child)	5.55 (.65)	6.00 (.73)	.45 (.60)	5.68 (.91)	5.85 (.74)	.17 (.57)	.07
Social support Communication with parents about diabetes (parent)	9.77 (11.48)	19.27 (25.10)	9.50 (21.99)	18.85 (25.11)	14.96 (20.57)	-3.89 (21.80)	.025*
Knowledge Diabetes knowledge test score (child)	16.06 (4.49)	17.22 (4.93)	1.16 (3.23)	16.21 (5.63)	16.89 (4.93)	.68 (4.54)	.64
Health behaviors Diabetes selfcare rating scales (parent)	4.88 (1.17)	5.16 (.94)	.28 (.86)	5.04 (1.05)	4.66 (1.34)	-.38 (.79)	.003**
Health outcomes Urgent visits for diabetes in past three months (parent)	.57 (.97)	.13 (.37)	-.43 (.90)	.61 (.92)	.64 (1.34)	.04 (1.11)	.08
Health outcomes HbA1c % Reference ranges: 3.3 - 6.6 (Stanford); 3.6-6.7 (Kaiser)	8.47 (1.64)	9.33 (1.69)	.86 (1.58)	8.28 (1.89)	8.94 (1.60)	.66 (1.58)	.67

Figures 2-5 show the study results graphically, for self-efficacy (Figures 2a and 2b), communication (Figures 3a and 3b), selfcare (Figures 4a and 4b), and urgent visits (Figures 5a and 5b).

Figure 2a:

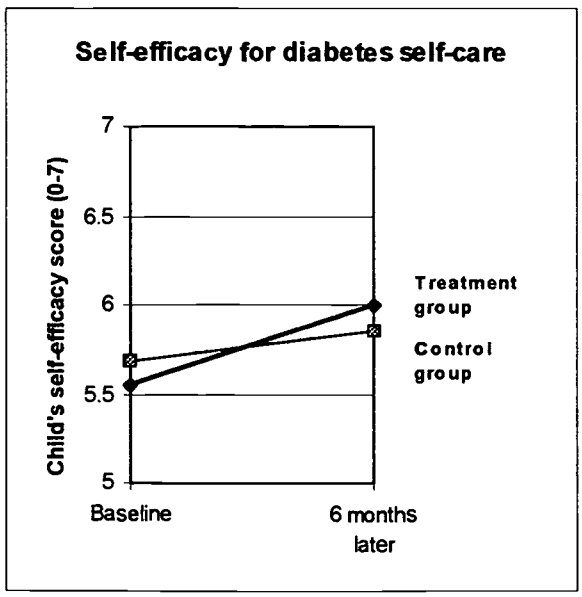


Figure 2b:

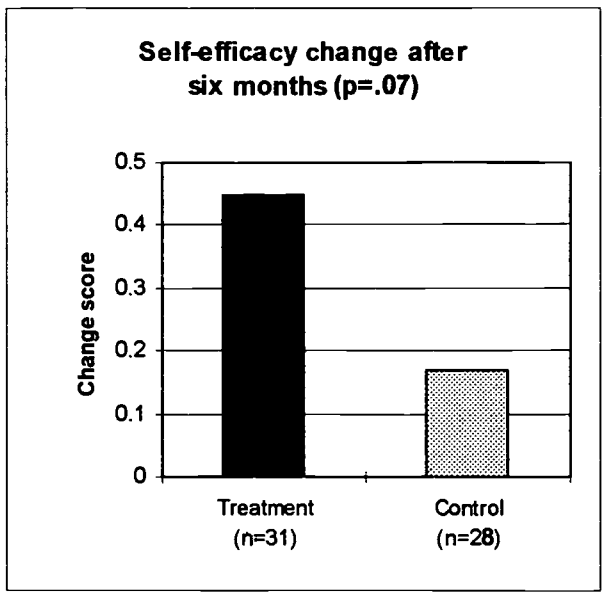


Figure 3a:

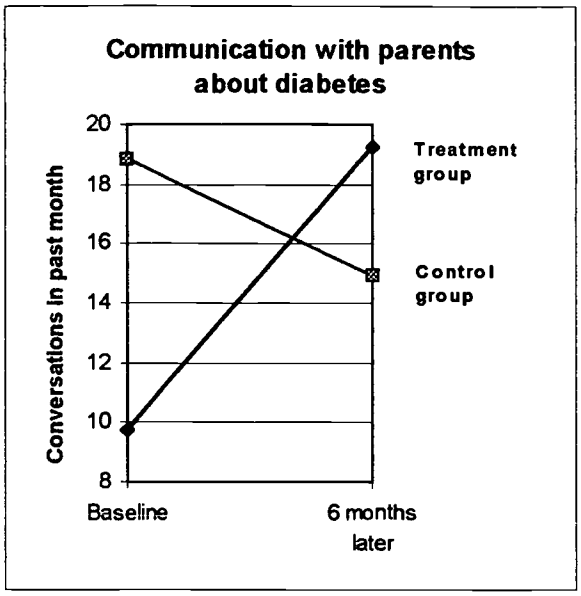


Figure 3b:

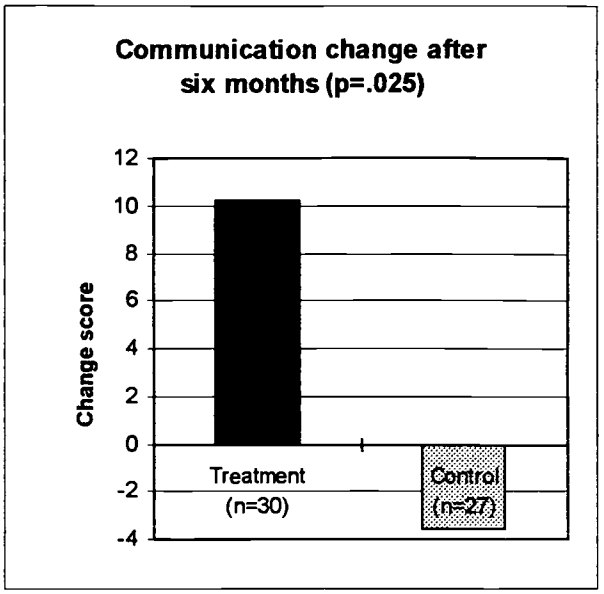


Figure 4a:

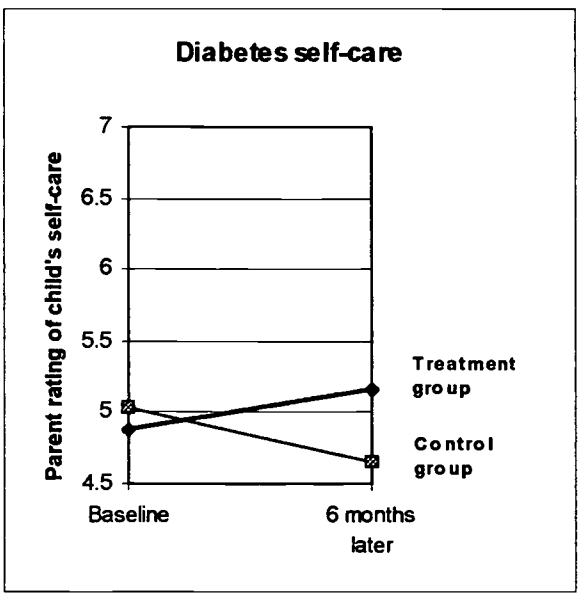


Figure 4b:

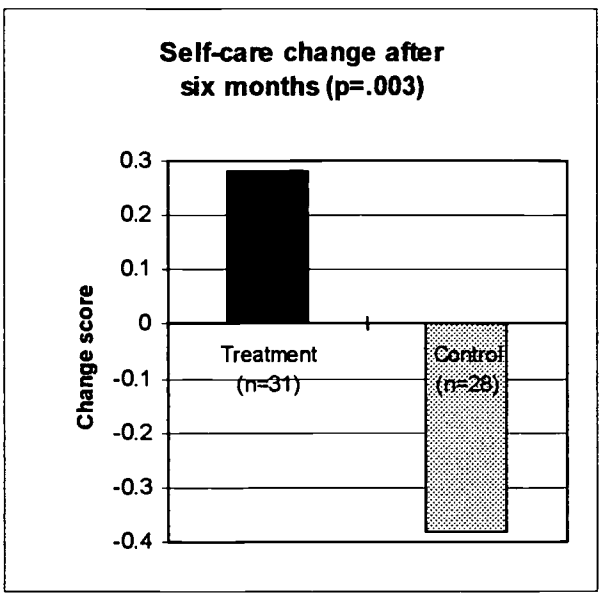


Figure 5a:

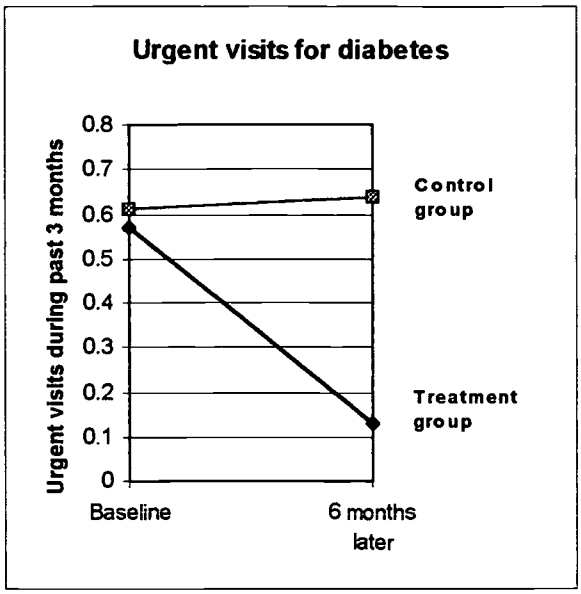
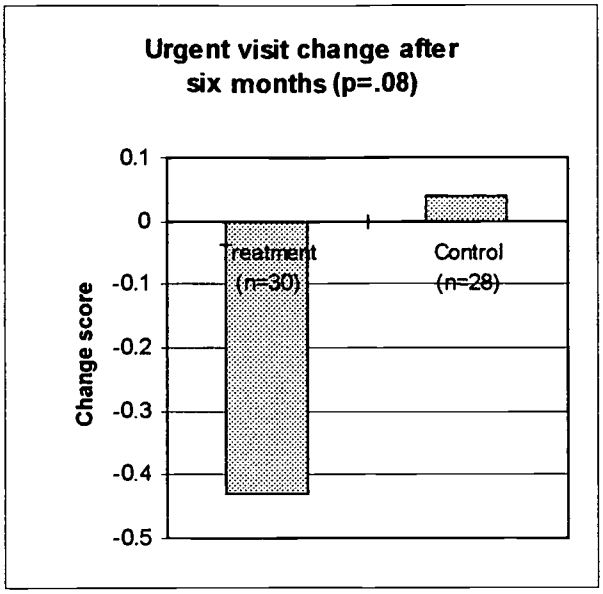


Figure 5b:



Relative to the control group, the treatment group gained in self-efficacy. This change was notable but did not reach a significance level of .05 or lower (p=.07, n.s.). The treatment group made significant gains in communication with parents about diabetes (p=.025), and significant gains in diabetes selfcare (p=.003).

Urgent doctor visits for diabetes-related problems declined in the treatment group but not significantly (p=.08, n.s.). The treatment group decreased from 17 urgent clinic visits in a three-month period to 5 visits, an average of .57 visits per child at baseline and .13 visits per child at the end of 6 months. The control group started with 17 visits (.61 per child) and increased to 18 visits (.64 per child) per three-month period at the end of the study. The intervention had no discernible effect on diabetes knowledge or on HbAlc.

Discussion

This study demonstrates that a health education video game for children, created with theory-based instructional design, can significantly increase communication about one's own health with others, and improve selfcare behaviors. The study also strongly indicates that playing such a video game improves children's self-efficacy and leads to improved health outcomes as measured by decreases in urgent care visits.

As video game technology becomes more powerful, it will be possible to design health education video games that assess individual preferences, abilities, and learning styles, and that tailor the content and format to suit individual needs. For example, a video game that offered a wide variety of content and game challenges, and selected them based on players' performance, would have a better chance of improving health outcomes than a game that was one-size-fits-all. To appeal to a wider variety of children, formats such as strategy games, puzzles, and interactive stories could be offered.

Games can also be delivered online. This would have the advantage of allowing two-way communication between patients and game publishers, and between patients and healthcare providers. Game publishers could send updates to the game from a central computer, so young players would continue to be motivated to play, to see what's new this month. Healthcare providers could ask young patients to play games that are based on the patient's own health status. Online downloading of data from physical measurement devices such as blood glucose meters could help clinicians keep track of patient status. For example, diabetic patients could attach their blood glucose meters to the computer and game characters could then start the game with those blood glucose levels as a way to help patients understand their own condition and to let them rehearse appropriate selfcare. Patients could also play games online with other children who have the same chronic condition and they could participate in online diabetes support groups that are offshoots of the game-playing experience.

This study provides evidence that video games, a popular pastime for young people of all socio-economic groups, can be effective health education and therapeutic interventions. A major advantage is that children play them willingly and enthusiastically during leisure time.

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