Journal of Diabetes Science and Technology
Volume 5, Issue 2, March 2011

SYMPOSIUM

Virtual Reality and Interactive Gaming Technology for Obese and Diabetic Children: Is Military Medical Technology Applicable?

Major Thomas "Brett" Talbot, M.D., M.S., FAAP

Abstract

The Telemedicine and Advanced Technology Research Center has pursued a number of technologies that may have application to the problems of obesity and diabetes management in children. Children are getting fatter because of increased caloric intake and less physical activity. Furthermore, technology advances have failed to significantly improve metabolic control of type 1 diabetes. Behavioral strategies should target video games, mobile phones, and other popular items used by children and seen by them as necessities. Exergaming is considerably more active than traditional video gaming and can be equivalent to moderate-intensity exercise. Diabetes equipment such as continuous glucose monitors and insulin pumps lack integration and live connectivity and suffer from a poor user interface. In contrast, mobile phones offer wireless connectivity, an excellent voice-enabled interface, and cloud connectivity that could possibly serve as a motivational and compliance tool for diabetes patients through text messaging to the patient, parents, and physician. Mobile phones have the potential to motivate and educate obese children as well. Exergaming for obese children could also be integrated into award systems of game consoles and game play time. The key to successful implementation of these strategies depends on the ability to integrate and connect the various technologies.

J Diabetes Sci Technol 2011;5(2):234-238

Introduction

Two ubiquitous challenges facing every pediatrician are the growing obesity epidemic and the long-standing quest for compliance among our type 1 diabetes patients. Technology in virtual reality (VR), interactive gaming, exergaming, and mobile tools has advanced very rapidly. The medical community is due for a reassessment of these technologies as they relate to obesity and diabetes. The military medical research community, through the U.S. Army Telemedicine and Advanced Technology Research Center (TATRC) and partners, has invested considerably in VR, interactive modalities, and information systems technologies that may be applicable to these broader health problems. This article evaluates the issue from the author's perspective as a futurist and pediatrician.

The TATRC (*www.tatrc.org*) is a medical advanced technology think tank and research funding center with the mission to confront over-the-horizon challenges with

Author Affiliation: U.S. Army Medical Research and Materiel Command, Fort Detrick, Maryland

Abbreviations: (A1C) hemoglobin A1c, (DDR) Dance Dance Revolution, (MMORPG) massive multiplayer online role playing game, (TATRC) Telemedicine and Advanced Technology Research Center, (VR) virtual reality

Keywords: blood glucose monitoring, exergaming, military health care, military readiness, pediatric diabetes , pediatric obesity, videogames, virtual environment, virtual reality

Corresponding Author: Major Thomas B. Talbot, M.D., M.S., FAAP, U.S. Army, Telemedicine and Advanced Technology Research Center, 1054 Patchel St., Fort Detrick, MD 21702; email address *Thomas.Talbot@TATRC.ORG*

high-risk and innovative approaches ahead of formal requirements. Research areas include robotics, nanotechnology, resilience and regeneration, medical simulation, and health information technology. Obesity is of interest to the Department of Defense because of resulting recruitment and retention difficulties as well as increased health care expenses. Diabetes costs are a great burden on the military health care system becuase of the number of dependents and retirees affected by the condition.

In regards to obesity, children have fared poorly with the advent of technology. Children now experience reduced outside playtime, reduced gym class time, and less recess coupled with increased consumption of take-out food, premade meals, and high sugar content beverages. As a result, childhood obesity is now three times as prevalent as it was back in the 1960s.[1] These children are at a significantly elevated risk for adult obesity, prediabetes, and type 2 diabetes mellitus. Pediatricians, like the author, attempt to recommend improving diet and exercise but face the barrier of family eating habits. Children, in turn, complain to them of limited opportunities for physical activity. This more obese cohort will also be considerably less fit for military service, adding expense and effort to shape new recruits.[1,2]

Children with type 1 diabetes, all of whom are insulin dependent because of autoimmune destruction of pancreatic islet cells, have enjoyed tremendous technological advances such as very long-acting glargine insulin, insulin infusion pumps, and continuous glucose monitors. With these advances, we have seen fewer severe hypoglycemic events, episodes of diabetic ketoacidosis, and hospitalizations. The problem remains with compliance, which is borne out by the fact that the gold standard hemoglobin A1c (A1C) measurements for metabolic control have remained unchanged despite these technological advances.[3] Because higher A1C levels are predictive of graver adult outcomes, pediatricians agonize over how to obtain better compliance and A1C results for their patients. Many pediatricians feel that their efforts are Sisyphean.

Youth and Technology

A basic approach to understanding which technologies suit children and teens can be inferred from how they are using technology. Kids spend significant time engaged in video games, with boys more likely to play console shooting games, girls more likely to play online casual games, and both engaging in virtual environments such as massive multiplayer online role playing games (MMORPGs). Major examples of MMORPGs include *Wizard 101*,[4] which targets younger children, and *World of Warcraft*,[5] which targets teens to adults. The MMORPG designers are masterful creators of leveling, achievement, and award systems that motivate (some say addict) players who will often spend considerable time doing repetitive and laborious activities in order to earn these achievements. Console game systems employ bragging points, vanity gifts, and virtual currency as motivators.

The child and teen ownership rate of mobile phones has reached 75%. Of interest, the majority of all teens employ mobile phones to send more than 1500 text messages per month. One-third of all teens send more than 3000. For teens, the text message modality exceeds all other forms of communication, including voice calls and out-of-school personal interaction.[6] This pattern of technology use represents a shift away from voice calls, social networking sites, and email.

Some technologies are less likely to be practical for children. The TATRC has funded successful full-immersion VR exposure therapy for treatment of post-traumatic stress disorder.[7] This useful modality has much more limited potential for busy teens because of requirements to visit a facility or have access to expensive display equipment. Another approach that is not likely to be successful includes obvious games about nutrition and health choices; kids are sophisticated consumers, and they already know they are supposed to choose the alfalfa frittata with celery over the cheeseburger and milk shake. For nutrition, a more sophisticated approach is required. The important question is, how can we reach youths through technology that they already use?

Exergaming

One technology that has been rapidly gaining use has been exergaming. The first commercially successful exergame was Konami's *Dance Dance Revolution*™ (DDR) and similar arcade games that employed a sensory surface for musical dance games. *Dance Dance Revolution* included hip music, enjoyable activities, and team play to allow socially competitive participation. The home versions of DDR were less successful due to the cost and low quality of home dance mats.

The next wave that expanded exergaming came from the Nintendo Wii console and Wii Fit platform. The console employed wireless accelerometer-based controllers that allowed natural intuitive movements. The Wii platform emphasized casual, sports, and exercise games that appealed to children and a higher percentage of girls.

Indeed, the Wii Fit step/balance platform was the hot Christmas item in 2008.

The Wii platform has been evaluated for exercise potential, and initial evaluations indicated that "active computer games use significantly more energy than playing sedentary computer games but not as much energy as playing the sport itself,"[8] thus concluding that the intensity of *Wii Sports* games were not high enough to meet children's exercise needs. Another study compared *Wii Sports*, DDR, and treadmill activity and drew more positive conclusions, stating that specific activities such as DDR and *Wii Sports: Boxing* were equivalent to a 5.7 km/h treadmill.[9] Potential differences in exergaming behaviors between obese and normal-weight players are not known but merits investigation.

The newest generation of exergaming comes from new real-time depth-sensing camera systems with embedded three-dimensional skeletal tracking such as Microsoft Kinect™. Similar technology was used in Department of Defense research before, but it was very expensive and required multiple cameras and special tracking markers. Today, this technology is available for home use at around $150. The benefit is completely controllerless gaming and full-active movements that appear to produce a higher intensity active gaming experience, although studies are needed to evaluate the energy expenditure from this technology.

Additional research is needed to understand how self-image serves as either a positive or negative motivator. The author has heard anecdotes from users of the Wii Fit that the exploding size of their avatar due to being weighed by the device discouraged them from ever using it again. In contrast, *The Biggest Loser Ultimate Workout* exergame employs obese exercise partners as part of an apparent motivational strategy.[10] The act of self-visualization as a VR avatar along with projective physical changes may serve to motivate and reinforce desired diet and exercise behaviors.[11,12]

The TATRC science experts view exergaming and interface technology like Kinect as transformational and are investing heavily into exergaming for soldier physical fitness using a variety of systems. The TATRC is spearheading a large effort to adapt the Kinect technology to a physical therapy application. Another effort employs biomonitoring with a mobile phone avatar that offers emotionally cognizant feedback to impaired soldiers on exercise and a dynamic motivational music track that alters with vital signs while exercising.[13–15]

Diabetes Management

Compliance with diabetes management is problematic, especially for children and teens. Children with diabetes start with a baseline level of compliance acquired from demonstrated parental behavior. As they grow, responsibility transitions to teens who often desire to downplay their affliction and spend as little time as possible thinking about their diabetes. Many pediatricians aim for "good enough" compliance, as few teens succeed as aggressive managers. Based upon research, we do know that keeping parental involvement high through shared responsibility, keeping communications open with the physician, and interventions such as motivational interviews are all contributors to more frequent testing, improved compliance, and tighter metabolic control.[16–18]

Since 2000, the TATRC has invested in approximately 120 diabetes-related projects. One effort, the Pediatric Diabetes Education Portal, included education, practical management advice, feedback from finger stick A1C tests, and continuous glucose monitoring tools as well as direct physician access. The 3-month result from a 50-child study was an impressive reduction in A1C from 9.6% to 6.9%.[19] Additional research includes a cell phone reminder system and a method for advanced noninvasive glucose monitoring based upon live physiologic data.[20]

The Bayer Didget™ is a bold and unique glucose meter that can interface with both a personal computer and a handheld Nintendo DS game system. It is designed to encourage compliance through awards via a game and a Web site.[21] However, the system is complicated to interface with, and unfortunately, there is currently only one game that responds to glucose meter use.

Doctors want their patients to use new tools such as infusion pumps, carbohydrate counting strategies, continuous glucose monitors, and even the new infusion pump and continuous monitor combination devices.[22] A major problem for patients is the time and inconvenience involved in their use and the primitive, limited, and difficult user interfaces of the device, often a one-line text or numeric display. The connectivity and interface issues are technology gaps that must be addressed to facilitate convenience of use.

An Integrated Behavioral and Technology Solution

A promising solution and big behavioral stick for improving metabolic control for diabetes patients and

encouraging exercise for obese youths is to tie access to technology that they strongly desire to their physical performance in daily life. Youths view mobile phones, text messaging, and video games as necessities.

A solution for diabetes patients is at hand: their phones. Mobile phones have rich graphical displays, embedded speech recognition capability, and local wireless device connectivity. These phones could easily interface wirelessly with an infusion pump/continuous glucose monitor and show a rich display of glucose trends, finger sticks, and other data. Since phones now have computational power approximating computers from 10 years ago, they can host well-featured applications for interpreting glucose results, possibly integrating sensor data for vital signs from the pump probe or a watch. The pump control application could have simplified carbohydrate counting with voice input (1/4 lb. hamburger, small fries, 16 oz. diet soda, and one apple) and suggest an infusion bolus that can be ordered from the phone.

Another aspect of phone integration is availability of cloud computing. It will be possible for the patient's physician, parents, and even an emergency monitoring service to have real-time and comprehensive data from the patient, practically eliminating the need to maintain or fabricate log books. Obtaining such data is a physician's dream and also allows teens to think less negatively about their diabetes. Troublesome results can be flagged and reported via text message. Forgetful compliance can trigger reminder text messages and a gradual reduction in phone capabilities until glucose is checked or a bolus is considered. Prolonged lack of compliance can be reported to parents in real time. Conversely, positive performance may reward the child.

Mobile phones also have a role for obesity management. Outdoors, they have a global positioning system that can calculate distance walked or run, speed, and general activity. This can also be coupled with physiologic sensors. Phones can also motivate and encourage activity. Exergaming activity could also be rewarded through achievements and privileges with their game system's online environment. Lower levels of desired behaviors can be tied to more restricted game privileges. The key to awards and privileges is that they apply to all games on the system. From an educational perspective, VR training sessions, possibly on a mobile device, could enable obese youths to rehearse making realistic nutrition exchanges so that they can eat the foods they desire yet reduce total calorie and fat intake. These integration and support concepts are consistent with work that TATRC is already doing to employ mobile phones for a variety of health applications.[23-29]

Conclusion

Success in improving obesity and diabetes management in children and teens through technology requires (1) an understanding of the patient's behavioral motivations and pattern of use of technology and (2) a strategy to tie desired behaviors to rewards and consequences. Actively motivating patients and involving parents is associated with better outcomes. The technology to achieve this vision now exists but requires novel integration and connectivity to make it work. The ability for these technologies to talk to each other and to track and visualize data from the "cloud" is the next technology gap to close. Military research and development such as TATRC's involves creating robotic surgeons, bionic limbs, wireless biomonitors the size of Band-Aids, and many other very challenging developments. Exploring creative ways to employ and interconnect existing technology for obesity and diabetes management is a relatively simple and achievable goal. The key is in the creativity applied to the task.

Disclaimer:

The opinions expressed in this article reflect the personal views of the author and not the official views of the United States Army or the Department of Defense.

Funding:

This work was supported by the U.S. government.

Acknowledgments:

Thanks to Albert "Skip" Rizzo, Ph.D., at the Institute for Creative Technologies who spent considerable time in demonstrating "Virtual Iraq" as a VR exposure treatment for post-traumatic stress disorder.

References:

1. Ogden C, Carroll M. NCHS health e-state: prevalence of obesity among children and adolescents: United States, trends 1963-1965 through 2007-2008. Centers for Disease Control and Prevention. http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm.
2. MISSION: READINESS. Too fat to fight: retired military leaders want junk food out of America's schools, report by mission readiness: military leaders for kids. cdn.missionreadiness.org/MR_Too_Fat_to_Fight-1.pdf. Accessed February 17, 2011.
3. Phillip M, Battelino T, Rodriguez H, Danne T, Kaufman F; European Society for Paediatric Endocrinology; Lawson Wilkins Pediatric Endocrine Society; International Society for Pediatric and Adolescent Diabetes; American Diabetes Association; European Association for the Study of Diabetes. Use of insulin pump therapy in the pediatric age-group: consensus statement from the European Society for Paediatric Endocrinology, the Lawson Wilkins Pediatric Endocrine Society, and the International Society for Pediatric and Adolescent Diabetes, endorsed by the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care. 2007;30(6):1653–62.
4. KingIsle Entertainment. Wizard 101. http://wizard101.com. Accessed December 2010.
5. Blizzard Entertainment. World of Warcraft. http://worldofwarcraft.com. Accessed December 2010.
6. Lenhart A, Ling R, Campbell S, Purcell K; Pew Internet and American Life Project; Pew Research Center. Teens and mobile phones. http://pewinternet.org/Reports/2010/Teens-and-Mobile-Phones.aspx. Accessed April 20, 2010.
7. Rizzo AS, Difede J, Rothbaum BO, Reger G, Spitalnick J, Cukor J, McLay R. Development and early evaluation of the Virtual Iraq/Afghanistan exposure therapy system for combat-related PTSD. Ann N Y Acad Sci. 2010;1208:114–25.
8. Graves L, Stratton G, Ridgers ND, Cable NT. Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. BMJ. 2007;335(7633):1282–4.
9. Graf DL, Pratt LV, Hester CN, Short KR. Playing active video games increases energy expenditure in children. Pediatrics. 2009;124(2):534–40.
10. The Biggest Loser Ultimate Workout for Xbox Kinect. www.xbox.com/kinect. Accessed February 17, 2011.
11. Fox J, Bailenson JN. The use of doppelgängers to promote health behavior change. Cyberther Rehabil. 2010;3(2):16–7.
12. Yee N, Bailenson JN. The difference between being and seeing: the relative contribution of self-perception and priming to behavioral changes via digital self-representation. Media Psychol. 2009;12(2):195–209.
13. Matthews M; Blitz! Games Studios. Vitalize! Game-based wellbeing. TATRC project 5053. Email medsim@tatrc.org for information.
14. Haynes J; Intelligent Automation, Inc. PATRICIA: A Personal Affective Therapist for Rehabilitation of Individuals with Cognitive Impairments. TATRC project 4247. Email medsim@tatrc.org for information.
15. Telemedicine and Advanced Technology Research Center. The TATRC medical simulation portfolio. http://www.tatrc.org/?p=ports/medSim/home. Accessed February 17, 2011.
16. Helgeson VS, Reynolds KA, Siminerio L, Escobar O, Becker D. Parent and adolescent distribution of responsibility for diabetes self-care: links to health outcomes. J Pediatr Psychol. 2008;33(5):497–508.
17. Holmes CS, Chen R, Streisand R, Marschall DE, Souter S, Swift EE, Peterson CC. Predictors of youth diabetes care behaviors and metabolic control: a structural equation modeling approach. J Pediatr Psychol. 2006;31(8):770–84.
18. Channon SJ, Huws-Thomas MV, Rollnick S, Hood K, Cannings-John RL, Rogers C, Gregory JW. A multicenter randomized controlled trial of motivational interviewing in teenagers with diabetes. Diabetes Care. 2007;30(6):1390–5.
19. Pinsker J; Tripler Army Medical Center. The Pediatric Diabetes Education Portal (PDeP). TATRC project 4686. AAMTI grant 2007011176. Email medsim@tatrc.org for information.
20. Telemedicine and Advanced Technology Research Center. 2008 annual report. http://www.tatrc.org/docs/TATRC_report_2008.pdf. Accessed February 17, 2001.
21. Bayer Healthcare. Bayer Didget™. http://bayerdidget.com.
22. Medtronic. MiniMed Paradigm REAL-Time Revel™ insulin pump and continuous glucose monitoring system. http://www.medtronic.com/your-health/diabetes/device/insulin-pumps/paradigm-real-time-system/index.htm.
23. Svoren BM, Volkening LK, Butler DA, Moreland EC, Anderson BJ, Laffel LM. Temporal trends in the treatment of pediatric type 1 diabetes and impact on acute outcomes. J Pediatr. 2007;150(3):279–85.
24. Thompson D, Baranowski T, Buday R, Baranowski J, Thompson V, Jago R, Griffith MJ. Serious video games for health: how behavioral science guided the development of a serious video game. Simul Gam. 2010;41(4):587–606.
25. Eckstein M. Cell phones a major Army health care tool. Frederick News Post. April 29, 2010.
26. Berg CA, Butler JM, Osborn P, King G, Palmer DL, Butner J, Murray M, Lindsay R, Donaldson D, Foster C, Swinyard M, Wiebe DJ. Role of parental monitoring in understanding the benefits of parental acceptance on adolescent adherence and metabolic control of type 1 diabetes. Diabetes Care. 2008;31(4):678–83.
27. Cope JU, Morrison AE, Samuels-Reid J. Adolescent use of insulin and patient-controlled analgesia pump technology: a 10-year Food and Drug Administration retrospective study of adverse events. Pediatrics. 2008;121(5):e1133–8.
28. Nakhla M, Daneman D, Frank M, Guttmann A. Translating transition: a critical review of the diabetes literature. J Pediatr Endocrinol Metab. 2008;21(6):507–16.
29. Swift PG. Diabetes education in children and adolescents. Pediatr Diabetes. 2009;10 Suppl 12:51–7.