President's Council on Physical Fitness and Sports

Research Digest

Series 9, No. 3 Sept. 2008

Promoting Physical Activity Using Technology

There is no question that technology has changed our lives. Many of these changes, from a physical activity (PA) and public health point of view, are negative: we drive to work or shop, we watch TV or sit in front of computers for many hours, we "Google," we chat online, we communicate through "texting," we make friends through "Facebook." As a result of all these changes, we have lost many low-to-moderate intensity activities from our daily lives and many of us now live a sedentary lifestyle. Well-documented scientific evidence has demonstrated that a sedentary lifestyle is one of the leading causes for most of today's health problems and chronic diseases, such as obesity, heart disease, cancer, diabetes, etc. One may wonder, since technology is one of the causes of today's sedentary lifestyle and health problems, how can it help promote PA? As Chinese Tao philosophy says, fortunately, everything has two sides. This is true also for technology. While technology indeed has had many negative impacts on a physically active lifestyle, it has great potential to help promote PA. This article will provide a description on how technology can help promote PA. After providing a brief review on some technologies that have been used in the field of PA promotion for many years, the article will discuss several new and emerging technologies that have great potential to help promote PA on a large scale. Then, persuasive technology, the technology developed and used for attitude and behavior change, will be introduced as a framework for our future technology development and application for PA promotion. Finally, critical practical issues related to technology applications will be briefly examined and addressed.

Note that this article does not plan to include a review of all technologies that have been employed in kinesiology, e.g., computerized training and assessment devices being used in laboratory settings. Rather, the focus will be on the technology that can help promote PA and change exercise behaviors on a large scale in free-living settings. This article will not provide a comprehensive literature review on each technology and related applications, although some key research studies will be cited.

Technology and PA Promotion Applications

Technology is no stranger to PA promotion. In fact, it has been around for a long time. According to technology characteristics, most of these already-used technologies for PA promotion can be classified into three categories: electronic gauges/devices, telephone, and mass media. They are described below, respectively.

Electronic Gauges

Electronic gauges are electronic devices that monitor PA by detecting and processing either mechanical movement of the human body or through bio-electronic signals associated with movement. While most of the electronic gauges are used for measuring PA or its related produced energy expenditure (EE), they could also play an active role by providing feedback to users and motivating them to do more PA. The most popular electronic gauges include pedometers, accelerometers, and heart rate (HR) monitors.

Pedometer. The pedometer, known also as a step counter, is a device which records walking steps taken. The pedometer is the oldest and most popular device for measuring, recording and promoting PA (Bassett & Strath, 2002). It was believed that the first non-electronic pedometer was conceived by Leonardo da Vinci in the 15th century for military applications (Montoye et al., 1996). The real development and usage of pedometers to measure and promote PA started in Japan in the 1960s. In 1965, the Japan Walking Association invented the "10,000 steps/day" slogan and Yamasa, a Japanese company, produced a non-electronic pedometer called "Manpo-meter," where "Manpo" means "10,000 steps" in Japanese (Hatano, 1993). Eventually, the device was electrified and computerized. The relationship between steps and EE was soon established and integrated into pedometers. Yamasa developed and released the first calorie-meter type of pedometer in the 1980s. Pedometers were picked up by the U.S. researchers in the late 1980s and started to become popular in PA promotion in the 1990s. Today, millions of pedometers have been sold in the U.S. alone and are used in various PA settings.

Pedometers are used mainly for measuring and monitoring steps in PA promotion. In addition, pedometers can be a motivation tool. Because walking is the most popular PA mode, walking, along with pedometers, has become one of the most popular means of PA promotion (Williams et al., 2008). According to two recent reviews, pedometer-based walking has been demonstrated to be associated with significant increases in PA and decreases in body mass index (BMI) and blood pressure (Bravata et al., 2008), and has resulted in a modest amount of weight loss (Richardson et al., 2008). Two key research

Published quarterly by the
President's Council on
Physical Fitness and Sports
Washington, D.C.

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questions related to walking and PA promotion have been: (a) how many days are needed to detect a person's usual walking behavior and (b) how many steps are needed either to maintain or improve one's health or weight management? The questions were addressed in the recent "Walking for Health" supplement of *Medicine & Science in Sports & Exercise*. A reliable estimate of a person's walking behavior can be completed in as little as three days although Sunday is well-known for having low step counts (Baranowski, Masse, Ragan, & Welk, 2008). For adults, <5000 steps per day is considered "Sedentary," 5000-7499 "Low active," 7500-9999 "Somewhat active," ≥10,000-12,499 "Active," and ≥12,500 "Highly active;" and children and youths' standards are emerging and more steps at each activity level are expected (Tudor-Locke et al., 2008). More detailed information on pedometers can be found in an excellent review by Tudor-Locke in the June 2002 issue of *Research Digest* and other PA measurement texts (LaMonte et al., 2006; Montoye et al., 1996; Welk, 2002a).

Accelerometers. Similar to pedometers, accelerometers are small portable electronic devices that can measure PA by recording minute-by-minute data of body acceleration and report the data as activity counts per minute. Activity counts can then be used to estimate energy expenditure (Welk, 2002b). Accelerometers are usually worn on the waist and can store data for long periods with flexible recording intervals. Differing from the pedometer, which can only measure steps taken, accelerometers can sense and record movement during a variety of activities and can provide detailed information on frequency, duration, and intensity, and patterns of these activities engaged in by a person. However, accelerometers cannot measure certain activities, such as movement involving only the upper body or water-related activities (Welk, 2002b). Accelerometers have shown acceptable validity and good reliability (Plasqui & Westerterp, 2007) and have been accepted as an accurate objective field measure for PA (Freedson & Miller, 2000). Very recently, a major effort has been made to include an accelerometer in the national surveillance system that monitors secular trends in behavioral and biological health indicators within the U.S. population. Specifically, between 2003 and 2006, the ActiGraph (ActiGraph, Fort Walton Beach, FL) accelerometer was included in the National Health and Nutrition Examination Survey (NHANES) to objectively measure and monitor PA among the U.S. population. As a result of this effort, several research reports (e.g., Matthews et al., 2008; Troiano et al., 2008) have been generated, which, for the first time, provide an estimation of physical activity participation in the U.S. based on an objective measure. Accelerometers have been reported being used in many research studies to assess various types, intensity and duration of PA. The high cost of accelerometers (about $300 per unit) is another limitation. Because of this limitation, accelerometers have been used mainly in research studies, rather than in large scale PA promotion settings.

Heart rate monitor. Heart rate (HR) is a physiological variable that is closely related with PA intensity. HR is the earliest field measure of PA and has been widely used to estimate EE since 1907 (Montoye et al., 1996). HR has been used to estimate EE based on the assumption of a linear relationship between HR and oxygen uptake (VO_2) (Wilmore & Haskell, 1971). HR is, however, sensitive to age, gender, temperature, humidity, fatigue, hydration, training status, and emotional stress and EE estimated by HR can be biased by these factors (Rennie et al., 2000). In addition, the HR monitor itself sometimes can be interrupted or delayed in catching each heart beat (Montoye et al., 1996). While a combination of HR and motion monitoring may overcome some of the limitations above, the need to develop individual HR-VO_2 calibration curves and instrumentation costs (about $500 per set) make this method less suitable for PA assessment in free-living settings (LaMonte et al., 2006). Nevertheless, the HR monitor has often been used in PA promotion, mainly for monitoring exercise intensities for highly active individuals (e.g., runners; Torok et al., 1995) and monitoring patients in their rehabilitation process (Adams et al., 2008). In addition, HR programs targeting school children have been created and implemented in many U.S. schools (Kirkpatrick & Birnbaum, 1997).

Telephone

The telephone has been used mainly for surveying PA participation of the population and for PA interventions. With a few exceptions (e.g., using ActiGraph for a subsample in the NHANES), all major national surveillance systems (e.g., Behavioral Risk Factor Surveillance System [BRFSS]) use the telephone to survey the U.S. population concerning their PA participation. The telephone thus plays a critical role in monitoring the level of the population's PA participation. For PA interventions, the telephone played mainly a delivery role. According to a recent review (Eakin, 2007), in which 26 phone-based studies (sixteen on PA, six on dietary behavior, and four on both) were identified and reviewed; the telephone was shown as an effective way to deliver a PA and dietary intervention and led to significant behavior changes. The authors have suggested translating the telephone-based interventions to the population level. However, based on a review of literature, others (Marcus et al., 1998) noticed that the effectiveness of telephone-based interventions is only short-term. More long-term studies on telephone-based PA promotion are needed. Additional information on the mobile phone and its applications and potential are described in a later section, "New and Emerging Technology and Applications."

Mass Media

Mass media refers to the communication methods that can reach large groups of people quickly and effectively. Although there are many types of mass media, the most popular, traditional media types are radio, television and print media (e.g., newspapers and magazines). The Internet and Web are rapidly eclipsing traditional mass media. Mass media that has been employed for PA promotion is usually based on a behavioral change theory (e.g., social marketing or social cognitive). According to a comprehensive review (28 studies were identified after screening more than 200 studies), Marcus et al. (1998) concluded that, although recall of mass-media messages generally was high, mass-media campaigns have very little impact on PA behavior change. There is a need for more research on how to improve media-based PA interventions, especially for socially disadvantaged groups (e.g., low income and the elderly).

New and Emerging Technology and Applications

The 20th century was one of the most exciting centuries for technology inventions. Among them, the birth of the computer and the Internet were the most significant developments. These technologies, along with a number of other emerging technologies (e.g., interactive technology, mobile phone/wireless technology, GPS/GIS, voice recognition, etc.), are being quickly utilized as modes for PA promotion. These technologies and related applications are described below.

Information Technology

Information technology (IT) refers to the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware. Among countless IT inventions and applications that have significantly changed our

lives in the information age, the Internet and World Wide Web are among the most significant ones. Two major applications of the Internet for PA promotion are information dissemination and intervention delivery. Hundreds of thousands of websites have been developed to provide the public PA-related information. According to some statistics a few years ago, more than 70,000 health-related websites are available on the Internet (Pagliari & Gregor, 2004) and more than 68 million people have been influenced by the information. A quick Google search using "Physical Activity," brought up a total of 24,900,000 hits in 0.23 seconds! While the quality of some of the information provided may be questionable, it is very easy for a user to find needed information and make a judgment and selection accordingly. In addition, many government agencies (e.g., Centers for Disease Control and Prevention [CDC] and National Institutes of Health [NIH]) have developed websites to disseminate free PA information to the public. Two good examples of credible free places to gain access to physical activity information are PubMed (http://www.ncbi.nlm.nih.gov/pubmed/), a health and medical literature database, and the CDC's PA website (http://www.cdc.gov/nccdphp/dnpa/physical/index.htm). In fact, CDC's website on the "U.S. Obesity Trends" (http://www.cdc.gov/nccdphp/dnpa/obesity/trend/maps/) was so well-designed and informative (e.g., BMI obesity maps) that it is often cited and presented in many PA promotions.

The development of Internet-based interventions has been relatively slow. According to a literature review by Berg et al. (2007), only 10 Internet-based PA intervention studies were identified that met their inclusion criteria for study quality. The majority of reviewed studies was tailored to the specific characteristics of the participants and used interactive self-monitoring and feedback tools. Although the interventions seem more effective than a waiting list strategy, the authors called for more research on the added value of the Internet-based intervention, namely increased supervisor contact, tailored information, or theoretical fidelity. Berg and others' conclusions were supported by two other review studies of web-based PA studies by Vandelanotte et al. (2007) and Kroeze et al. (2006), respectively. Of the 15 web-delivered PA intervention studies reviewed by Vandelanotte et al. (2007), eight studies reported improvement in PA and the more contacts during the intervention, the better the intervention outcome. However, intervention effectiveness was short-lived and there was limited evidence of maintenance of PA changes. Of the 10 studies (four with PA only and six with PA and dietary behaviors) reviewed by Kroeze et al. (2006), only one was found having significant effects and one having "mixed effects" (i.e., within one study both significant and nonsignificant results were found for either different subgroups or different outcome measures). More studies are needed before introducing Internet PA intervention as a large-scale application.

Two new extended Internet functions, i.e., social networking and self-video publishing, may give Internet-based PA promotion a new dimension to explore. Two good examples of these functions are Facebook (http://www.facebook.com/) and YouTube (http://www.youtube.com/). Facebook is a social networking website launched in 2004 by Mark Zuckerberg while a student at Harvard University. Within a few years, the website had more than 90 million active users around the world. Researchers in persuasive technology, which will be introduced later, quickly realized the potential to use this new vehicle for mass behavior interventions. Dr. B.J. Fogg at Stanford University taught a class recently which had students create Facebook applications. Within 10 weeks, some of those applications reached 10 million Facebook users (Fogg, 2008). YouTube is a video-sharing website where users can upload, view and share video clips. It was created in 2005 by three former PayPal employees. Like Facebook, YouTube has reached a large group of active users worldwide within a few years. In January 2008 alone, nearly 79 million users had made over 3 billion video views posted to YouTube (Yen, 2008). There is a vital need to figure out how to take advantage of these new Internet opportunities to promote PA.

Interactive Technology

Interactive technology can be simply defined as any technology with interactivity, which in fact has been a characteristic of technology since its infancy (e.g., interactivity of the telegraph or later the telephone). The fast growth of interactive technology has led to the development of new interactive communication strategies, which have a great implication for population-based PA promotion (Marcus et al., 2000). The simplest example of interactive technology is Dance Dance Revolution (DDR; Lanningham-Foster et al., 2006). DDR is a video game that is played with a floor pad as the controller (also known as the dance platform) with multiple arrow panels in a grid formation. Playing DDR has been proven to be good aerobic exercise. Some regular players have reported weight loss of 10-50 pounds and one player reported that including DDR in her day-to-day life resulted in a loss of 90 pounds (American Diabetes Association, 2004). In many weight loss cases, individuals became motivated to take additional actions to lose weight, including incorporating nutritionally sound eating habits and seeking out additional recreational activities. School physical educators also quickly realized that DDR can be a wonderful vehicle to promote physical activity among the U.S. children whose obesity problem already has become an epidemic. Efforts, in fact, had been done to examine the benefits of DDR as a means for PA intervention. Studies (e.g., Epstein et al., 2007; Lanningham-Foster et al., 2006) showed that DDR has been effective in increasing children and youths' PA levels. Partnering with the West Virginia Public Employees Insurance Agency, researchers at West Virginia University recently developed a large-scale DDR intervention project called "West Virginia Games for Health," in which children play DDR five days a week for at least 30 minutes per day for 24 weeks. According to a recent press release by the research team, playing DDR improved the health, attitudes and behaviors of participating children (WVU Today, 2007). Similarly, many schools now incorporate DDR as a part of their physical education curriculums. Incorporating DDR into gym classes is part of a general shift in physical education, with school districts de-emphasizing traditional sports in favor of less competitive activities. Based on the current trend, it is expected more than 1,500 schools are likely to be using the game by the end of the decade. In Norway, DDR has even been registered as an official sport called "Machine Dance."

The Wii (pronounced as "we") is another good example of interactive technology application. The Wii is a home video game console by Nintendo (Kyoto, Japan). The name "Wii" was selected for marketing because it can easily be remembered by people around the world, no matter what language they speak. A distinguishing feature of the console is its wireless controller, the Wii Remote, which can be used as a handheld pointing device and detect movement in three dimensions. Based on these features, a number of games, e.g., bowling, boxing and tennis, were created. The interactive features generated attention and interest of millions of traditional game players and the public. It was launched in the U.S. November 19, 2006 and 10.61 million were sold by the end of that month ("Wii," 2008). Earlier this year, 2008, Nintendo launched Wii Fit, an exercise game consisting of activities using the Wii balance board peripheral. The game includes about 40 activities including yoga, strength training, aerobics, balance, etc. Wii Fit sold over a quarter of a million copies in the first week of its launch. Exercise and physical therapy communities picked up the Wii and Wii Fit right away

and some hospitals already use them in their rehab programs; the responses to their use have been very positive ("Wii," 2008). As expected, the true energy expenditure by doing video exercises was much lower than playing the real one (for example, Wii tennis versus really playing a match). According to Graves et al. (2007), playing Wii exercise games only increased EE about 2% when compared with playing normal "sedentary" games. Nevertheless, the authors agreed that playing exercise games will at least encourage positive behavior, especially in sedentary children. After reviewing 27 studies of 25 video games, Baranowski, Buday, Thompson, and Baranowski (2008) recently concluded that positive health-related changes can be made by playing these specifically designed video games. They called for more research on the optimal use of game-based stories, fantasy, interactivity, and behavior change technology for promoting health-related behavior changes.

Mobile/Cell Phone and Wireless Technology

Like the computer and Internet, the mobile phone is a great invention of the information age. Technically, a mobile phone functions like an extremely sophisticated radio. It is basically a wireless communication, which can trace its roots to the invention of the radio by Nikolai Tesla in the 1880s (formally presented in 1894 by a young Italian named Guglielmo Marconi). The concept of using hexagonal cells for mobile phone base stations was invented in 1947 by Bell Labs engineers at AT&T and further developed by Bell Labs (Murray Hill, New Jersey) during the 1960s. In 1970, Amos Joel of Bell Labs invented "call handoff" that allowed a mobile phone user to travel through several colloquy cells during the same conversation. Martin Cooper of Motorola (Schaumburg, Illinois) is widely considered to be the inventor of the first practical handheld mobile phone to use in a non-vehicle setting. Using a modern and somewhat heavy portable handset, Cooper made the first call on a handheld mobile phone in 1973 (for more historical aspects of the mobile phone, see: http://en.wikipedia.org/wiki/Cell_phone). Just a few years ago, the average mobile phone user was most likely to be wealthy. These days, according to the Cellular Telecommunications & Internet Association (CTIA, 2008), mobile phone users encompass all ages, races, and economic classes

PA promotion application. Development of the mobile phone has provided researchers with a convenient method for remote collection of a variety of data. For example, subjects in the past have had to come to a research laboratory to complete training and to provide or download their data. With mobile phones, these tasks can all be done at a distance. Subject burden is greatly reduced, thus making it possible to collect large amounts of data in population-based studies. Furthermore, the reminding system developed in the calling function should greatly improve the quality of the data collected. The mobile phone is already being used in PA research for tracking/monitoring (Arsand et al., 2008) and PA intervention delivery (Hurling et al., 2007). Anderson et al. (2007) reported an effort to estimate and track daily PA by analyzing Global System for Mobile (GSM) cell signal strength and visibility of mobile phones. Some commercial mobile phones have also included pedometer chips and some other advanced features for PA tracking (e.g., for more accurate measures they allow for the calibration step count and step distance, and can save the data for up to two weeks).

Texting: Another big possibility. Another application of mobile phones is text messaging, or simply texting. Texting is the common term for the sending of "short" (160 characters or fewer) text messages from mobile phones using the Short Message Service (SMS). It is available on most mobile phones and some personal digital assistants (PDA) with on-board wireless telecommunications. Short message services are developing very rapidly throughout the world. In 2000, just 17 billion SMS messages were sent; in 2001, the number was up to 250 billion, and in 2004 there were 500 billion SMS messages sent. At an average cost of $0.10 per message, this generates revenues in excess of $50 billion for mobile phone service providers and represents close to 100 text messages for every person in the world. Compared with other countries, the appeal of SMS was more limited in the U.S. for a number of years. However, the addition of Cingular-powered SMS voting on the television program "American Idol" introduced many Americans to SMS in 2002, and its usage quickly started rising. In the third quarter of 2006, for example, more than 10 billion text messages crossed Cingular's network, up almost 15 percent from the preceding quarter. In the U.S., while texting is widely popular among 10-25 year olds, it is becoming increasingly popular among adults and businesses as well. According to both the Mobile Marketing Association and Pew Internet & American Life Project Surveys, 40% of the U.S. mobile phone users use text messaging to communicate with other people ("Text messaging," 2008).

The potential of the mobile phone power was promptly recognized by health care professionals. According to a recent review (Adler, 2007), among the latest wireless technologies, texting will be the most convenient method in providing patient communication and support. A few texting applications in health care have also been reported, e.g., using text messaging to improve clinical and health promotion attendances (Battistotti et al., 2006) and to telemonitor mobility trends of elderly people (Scanaill et al., 2006). Although no specific PA application using texting has been reported, its potential should prove to be tremendous.

GPS and GIS

Widely available GPS and GIS technology also provides a new tool for PA promotion. GPS refers to Global Positioning System, which is a worldwide radio-navigation system formed from a constellation of 24 satellites and their ground stations. GPS uses these "man-made stars" as reference points to calculate geographic positions accurately within a few meters. With advanced forms of GPS, one can make measurements with accuracy to within a centimeter! GPS receivers have been miniaturized to contain just a few integrated circuits, making them very economical, and making the technology accessible to virtually everyone. GPS, at present, is finding its way into cars, boats, airplanes, construction equipment, movie-making gear, farm machinery, and even laptop computers. GPS will soon become almost as basic as the telephone and may become a universal utility. GIS (Geographic Information Systems) originally referred to a computerized system for asking questions of maps showing current and potential land use in Canada (Longley, Goodchild, Maguire, & Rhind, 1999). With the improvement of computing power, GIS has been applied to almost every field of study. It is now broadly defined as "a computer system for the input, storage, maintenance, management, retrieval, analysis, synthesis, and output of geographic or location-based information" (Longley et al., 1999). GIS has been widely used in public health research and information management (Cromley & McLafferty, 2002).

The major benefit of GPS/GIS is that it can accurately track where a specific activity happened, which in turn will help provide a better understanding of the interaction between people's PA and the surrounding environment. Using walking as an example: the pedometer, the most popular tool to track walking, can only tell us how many steps a person has taken, but it does not provide information on where, when and how the walk was completed. Neither is there other critical information on walking (e.g., which activities are combined within one chain of walking? How much do neighborhood environmental characteristics

contribute to a person's walking pattern? etc.). With a combination of GPS and a PA measure, the limitation of traditional direct PA measures can be eliminated. Some initial attempts (e.g., Rodriguez et al., 2005; Schutz & Herren, 2000; Terrier et al., 2000) have been reported in the application of GPS with PA measurements. Zhu (2003) further proposed a concept of physical activity space, which describes "the area or space where an individual spends time and engages in physical activity" and is measured using GPS. By integrating the information measured by GPS with GIS, the impact of environment on PA can be examined in detail. The studies based on the SMARTRAQ project (Frank et al., 2005), in which the impact of urban form and community design on PA was examined, are some good examples of GIS applications. More information on GIS and PA promotion can be found in Porter et al. (2004).

Speech Recognition and Text Classification

Two other technologies, namely speech recognition and text classification, have also a great potential for PA promotion. Speech recognition is the process of automatically extracting and determining linguistic information conveyed by a sound wave using computers or electronic circuits. Text classification, also known as text categorization, is used to classify pieces of text to predetermined categories based on content. Types of text could include documents, paragraphs, sentences or websites and types of categories could be determined by topic, function, author, style, etc. Using both technologies, an *e*-diary application was developed (Zhu et al., 2006). In the past, collecting and analyzing diary data had a high subject burden and was expensive. Yet the diary method is the only method that can provide PA participation pattern information and has been considered one of the criteria measures in PA research. The *e*-diary is able to collect data using a recorder, translate the recorded voice into text, and classify an activity into right categories (e.g., "I walked with a friend for 10 minutes"; "I walked the dog for 20 minutes in the park"; "I walked in the mall for 15 minutes" were some activities listed in the "walking" category) with about 87% accuracy. Many similar applications for the *e*-diary are expected in the coming years.

There are many other technologies that have been either applied to PA promotion (e.g., robot) or have a great potential for future PA promotion (e.g., radiofrequency identification [RFID] and nanotechnology) but it is impossible to cover all of them. Interested readers should refer to Freedson et al. (2008) and Nigg (2003) for more information.

Persuasive Technology/Captology: A Useful Framework

As illustrated above, PA promotion has made the effort to take advantage of technology when available. Most applications, however, have been focused on measuring and tracking PA habits whereas few were designed to hit the heart of PA promotion: change people's PA behaviors. Fortunately, the concept of persuasive technology and Captology, which are described below, will be helpful for future technology development and application in PA promotion. Persuasion is one of the most effective tools to help change others' attitudes or behaviors (Dillard & Pfau, 2002). Intentionality is the key for a true persuasion and not all behavior or attitude change is the result of persuasion. For example, the current sky-rocketing high price of gas has made many people give up or significantly decrease their driving, thus potentially increasing their physical activity. Gas price in this case, however, is not a persuasive event since people will likely change back to driving as soon as the price goes down. On the other hand, if the gas price or associated tax is purposely set very high by the government to encourage walking and bicycling as the major transportation mode, the high price would qualify as a persuasion event. In public health, this method (e.g., setting a high cigarette tax to discourage smoking behavior) has been employed and demonstrated effectively (U.S. Department of Health and Human Services, 2000).

Using available present-day technology to assist persuasion is almost as effective as persuasion itself (Fogg, 2003). The first major breakthrough in this relationship was the technology that allowed easier production and distribution of books, flyers, pamphlets, billboards and other forms of written and visual communication. With the introduction and advances of computers and other new technologies, persuasion based in technology is getting smarter. As a result, technology-centered persuasion is rapidly developing. Dr. B.J. Fogg (2003) of Stanford University introduced the term "persuasive technology," which he defined as "a computing system, device, or application intentionally designed to change a person's attitude or behavior in a predetermined way." He further coined the term "Captology," which he derived as a partial acronym for Computers As Persuasive Technologies (CAPT-ology), for this area of study.

Persuasive technology plays three roles in persuasion: tool (e.g., record steps in a convenient way using a pedometer), media (e.g., powerful images of obesity and diabetes trends by state and by year in the slide presentations created by CDC) and social factor (e.g., Wii boxing with another person). The applications of persuasive technology can also be easily seen in our daily life. While driving, we get instant feedback of our driving speeds from the Speed Monitoring Awareness and Radar Trailer (SMART) and reduce our speed if it is higher than the posted speed limit. A successful application of persuasive technology in health education is the Baby Think It Over Infant Simulator, which is a high-tech doll. Rather than lecturing teenagers on teenage pregnancy, teens are given the Baby Think It Over to take care of as if it was a real baby. After several days of being a "mom" or "dad" by taking care of the "baby," the teenagers learned the challenges of being a teen parent and they are eager to return the "baby" and resume their normal lives (Out & Lafreniere, 2001). The Nike+iPod shoe is also a good example of persuasive technology related to PA promotion, as it gives instant feedback from a running performance, which is encouraged by music. With only one or two exceptions, most technology applications in PA promotion were not designed under the persuasive technology framework and their roles in changing people's behavior are limited only to that of a "tool" (Zhu, 2007). Some very successful applications, such as DDR, were not initially designed for PA promotion. Yet, as the tool's interactive feature caught children and youths' interests right away, they play the game without knowing they are voluntarily doing something (e.g., exercise) that they have often refused to do. Understanding the unique persuasive features and power that the technology can bring to PA promotion is urgently needed.

While it is a very new field, persuasive technology and its related applications are growing rapidly. Three international conferences on persuasive technology have been conducted since 2006 and the interest has been extended to mobile phone- (Fogg & Eckles, 2007), texting-, and Facebook-based persuasions. The progress in these areas should bring additional application possibilities for PA promotion. Researchers in PA promotion should actively take advantage of new developments in this area and become involved in new technology and application development under the framework of persuasive technology.

Practical Issues Related to Technology Application in PA Promotion

Technology has great potential to help with PA promotion. Yet changing behavior, as we learned from many other means and

efforts, will never be an easy task. In addition, few studies have been conducted to examine the barriers and challenges in using technology for PA promotion. Summarized below are key factors in designing or implementing a technology-based PA intervention or promotion.

Designing and Selecting a Technology Application

While there are many factors one should consider when designing and selecting a technology application, the classic "KISS (Keep It Simple and Straightforward)" principle is perhaps the most important one. Basically, it states that one should keep a design simple and avoid unnecessary complexity. This is very true for technology applications. A good example in PA promotion is the pedometer. It became the most popular device in PA promotion mainly because it is simple to use. Other design factors to be considered include: (a) give users credit or reward for participation, (b) provide awareness of activity level, (c) provide social support, and (d) consider practical constraints of users' lifestyles (Consolvo et al., 2006).

Cost-Effectiveness

The cost-effectiveness of PA interventions was not studied until recently (see Munro et al., 2004; Sevick et al., 2007). According to a comprehensive, systematic review (Kahn et al., 2002), two informational interventions ("point-of-decision prompts" and "community-wide campaigns") and three behavioral and social interventions (school-based physical education, social support and individual-adapted health behavior change) were effective. Evidence, however, is insufficient to determine the cost-effectiveness of a number of other interventions (e.g., health education). More studies are clearly needed.

Special Populations

Because applying technology is often associated with technical complexity and cost, which may result in additional barriers to use in disadvantaged population subgroups (e.g., lower income families, older adults, and persons with disabilities; Hagberg & Lindholm, 2005). Thus, there is often a concern when promoting PA using technology among these subgroups, i.e., the technology itself may not be designed for the groups that need it the most. While every effort should be made to address this concern, the widespread integration and usage of high-tech devices in today's society makes the barriers relatively easy to eliminate. For persons with disabilities, technology may help circumvent traditional barriers. For example, transportation to a central location for an exercise intervention has long been perceived as a key barrier for people with disabilities. With the Internet, a personal trainer can be brought into one's home to provide individualized, adapted training. As an example, based on the AIMFREE instrument they developed, Rimmer et al. (2004) have developed and implemented a remote Internet-based rating system to examine and evaluate an exercise facility's disability accessibility.

Integration

One of the trends in today's technology application in PA promotion is integration, which includes integration between technology and behavioral theories, and among technologies. Since technology so far only acts as a "tool," the use of technology alone may not bring the needed intervention or promotion effect. Therefore, an existing behavior change or social marketing theory should be integrated with the technology application. Many reported applications (see King et al., 2008), in fact, have already done so. Meanwhile, one should not limit new technologies to these existing theories, rather one should be encouraged to explore other roles that technology can play (e.g., media and social actor, Fogg, 2003) and the new technology-centered theories (e.g., Captology). The second integration is to integrate multiple technologies into an application. By taking advantage of the strengths of each technology, an integrated application should be much more convenient and powerful. In fact, many attempts have been made to combine PA measurement and intervention delivery into a single application.

Interdisciplinary Team

Technology is so sophisticated today, experts in multiple technological domains are needed to create and develop, and implement an application into free-living population settings. On one hand, many neat applications are designed by technology specialists without taking into careful consideration the needs of the application side. As a result, these applications will likely lead to little or no impact. Thus, to be able to design and implement a useful technology application for PA promotion, an interdisciplinary team, consisting of PA researchers, technology experts, practitioners and users, is needed. How to create such a team and be able to work in a collaborative manner with such a team needs to be a part of the training of future PA researchers and community facilitators.

Conclusion

Technology has already changed our lives and we have used it for PA promotion for a long time. Newly developed technology and new ways of thinking concerning how to change people's attitudes and behaviors using technology have provided us with a new and exciting opportunity to promote PA on a much larger scale. To effectively design and implement a technology-based PA promotion/intervention, factors, such as design, cost, consideration of special populations, integration of technology with behavior change theories, and working with an interdisciplinary team, should be pursued.

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References

Adams, B.J., Carr, J.G., Ozonoff, A., Lauer, M.S., Balady, G.J. (2008). Effect of exercise training is supervised cardiac rehabilitation programs on prognostic variables form the exercise tolerance test. *American Journal of Cardiology, 101*(10), 1403-1407.

Adler, R. (2007). *Health care unplugged: The evolving role of wireless technology.* Oakland, CA: California HealthCare Foundation.

American Diabetes Association (2004, October). Active video games help dance off pounds: Thousands shed weight with popular game. *DOC News, 1*(2), 17. Retrieved January 19, 2008 from http://docnews.diabetesjournals.org/cgi/content/full/1/2/17.

Anderson, I., Maitland, J., Sherwood, S., Barkhuus, L., Chalmers, M., Hall, M., et al. (2007). Shakra: Tracking and sharing daily activity levels with unaugmented mobile phones. *Mobile Networks and Applications, 12*(2-3), 185-199.

Arsand, E., Olsen, O.A., Varmedal, R., Mortensen, W., & Hartvigsen, G. (2008). A system for monitoring physical activity data among people with type 2 diabetes. *Studies in Health Technology and Informatics, 136*, 113-118.

Baranowski, T., Buday, R., Thompson, D., & Baranowski, J. (2008). Playing for real: video games and stories for health-related behavior change. *American Journal of Preventive Medicine*, 34(1), 74-82.

Baranowski, T., Masse, L.C., Ragan, B., & Welk, G. (2008). How many days was that? We're still not sure, but we're asking the question better! *Medicine & Science in Sports & Exercise, 40, 7*(Suppl.), 544-549.

Bassett, Jr., D.R. & Strath, S.J. (2002). Use of pedometers to assess physical activity. In G. Welk (Ed.), *Physical activity assessments for health-related research* (pp. 163-177). Champaign, IL: Human Kinetics.

Battistotti, A., Quaglini, S., & Cuoco, E. (2006). Reducing dropouts in outpatient care through an SMS-based system. *Studies in Health Technology and Informatics, 124*, 935-1940.

Berg, M.H. van den, Schoones, J.W., & Vileland, T.P. Vliet (2007). Internet-based physical activity interventions: A systematic review of the literature. *Journal of Medical Internet Research, 9*(3), e26.

Bravata, D.M., Smith-Spangler, C., Sundaram, V., Gienger, A.L., Lewis, R., Stave, C.D., Olkin, I., & Sirard, J.R. (2008). Using pedometers to increase physical activity and improve health: A systematic review. *JAMA, 298*(19), 2296-2304.

Consolvo, S., Everitt, K., Smith, I., & Landay, J.A. (2006). Design requirements for technologies that encourage physical activity. In: *Proceedings of ACM CHI 2006 Conference on Human Factors in Computing Systems 2006* (pp. 457-466). ACM: New York.

Cromley, E.K. & McLaffferty, S.L. (2002). GIS and public health. New York: The Guilford Press.

CTIA (2008). *Annualized wireless industry survey results - December 1985 to December 2007.* Retrieved August 25, 2008 from http://files.ctia.org/pdf/CTIA_Survey_Year_End_2007_Graphics.pdf.

Dillard, J.P. & Pfau, M. (2002). *The persuasion handbook: Developments in theory and practice.* Thousand Oaks, CA: Sage Publications.

Eakin, E.G., Lawler, S.P., Vandelanotte, C., & Owen, N. (2007). Telephone interventions for physical activity and dietary behavior change: A systematic review. *American Journal of Preventive Medicine, 32*(5), 419-434.

Epstein, L.H., Beecher, M.D., Graf, J.L., & Roemmich, J.L. (2007). Choice of interactive dance and bicycle games in overweight and non-overweight youth. *Annals of Behavioral Medicine, 33*(2), 124-131.

Fogg, B.J. (2003). *Persuasive technology: Using computers to change what we think and do.* New York: Morgan Kaufmann Publishers.

Fogg, B.J. (2008). Mass interpersonal persuasion: An early view of a new phenomenon. In H. Oinas-Kukkonen et al. (Eds.). *Persuasive 2008, LNCS 5033* (pp. 23-34). New York: Springer.

Fogg, B.J. & Eckles, D. (Eds.) (2007). *Mobile persuasion: 20 perspectives on the future of behavior change.* Palo Alto, CA: Stanford University.

Frank, L.D., Schmid, T.L., Sallis, J.F., Chapman, J.E., & Saelens, B.E. (2005). Linking objectively measured physical activity with objectively measured urban from: Findings from SMARTRAQ. *American Journal of Preventive Medicine, 28*(2, Suppl. 2), 117-125.

Freedson, P.S., Bendley, K., Ainsworth, B.E., Kohl, III, H.W., Leslie, E., & Owen, N. (2008). New techniques and issues in assessing walking behavior and its contexts. *Medicine & Science in Sports & Exercise, 40, 7*(Suppl.), 574-583.

Freedson, P.S. & Miller, K. (2000) Objective monitoring of physical activity using motion sensors and heart rate. *Research Quarterly for Exercise and Sport, 71*, S21-S30.

Graves, L., Stratton, G., Ridgers, N.D., & Cable, N.T. (2007). Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: Cross sectional study. *British Medical Journal, 335*, 1282-1284.

Hagberg, L.A. & Lindholm, L. (2005). Is promotion of physical activity a wise use of societal resources? Issues of cost-effectiveness and equity in health. *Scandinavian Journal of Medicine & Science in Sports, 15*(5), 304-312.

Hatano, Y. (1993). Use of the pedometer for promoting daily walking exercise. *International Council for Health, Physical Education, and Recreation, 29*, 4-8.

Hurling, R., Catt, M., Boni, M.D., Fairley, B.W., Hurst, T., Murray, P., Richardson, A., & Sodhi, J.S. (2007). Using internet and mobile phone technology to deliver an automated physical activity program: Randomized controlled trial. *Journal of Medical Internet Research, 9*(2), e7.

Kahn, E.B., Ramsey, L.T., Brownson, R.C., Heath, G.W., Howze, E.H., Powell, K.E., et al. (2002). The effectiveness of interventions to increase physical activity: A systematic review. *American Journal of Preventive Medicine, 22*(4 SUPPL. 1), 73-107.

King, A.C., Ahn, D.K., Oliveira, B.M., Atienza, A.A., Castro, C.M., & Gardner, G.D. (2008). Promoting physical activity through hand-held computer technology. *American Journal of Preventive Medicine, 34*(2), 138-142.

Kirkpatrick, B. & Birnbaum, B.H. (1997). *Lessons from the heart: Individualizing physical education with heart rate monitors.* Champaign, IL: Human Kinetics.

Kroeze, W., Werkman, A., & Brug, J. (2006). A systematic review of randomized trials on the effectiveness of computer-tailored education on physical activity and dietary behaviors. *Annals of Behavioral Medicine, 31*(3), 205-223.

LaMonte, M.J., Ainsworth, B.E., & Reis, J.P. (2006). Measuring physical activity. In T.M. Wood & W. Zhu (Eds.), *Measurement theory and practice in Kinesiology.* Champaign, IL: Human Kinetics.

Lanningham-Foster, L., Jensen, T.B., Foster, R.C., et al. (2006). Energy expenditure of sedentary screen time compared with active screen time for children. *Pediatrics, 118*, e1831-1835.

Longley, P.A., Goodchild, M.F., Maguire, D.J., & Rhind, D.W. (1999). Introduction. In P.A. Longley, M.F. Goodchild, D.J. Maguire, D.W. Rhind (Eds.). *Geographical information systems: Principles and technical issues.* Vol. 1 (2nd ed.). New York: John Wiley & Sons.

Marcus, B.H., Nigg, C.R., Riebe, D., & Forsyth, L.H. (2000). Interactive communication strategies: Implications for population-based physical-activity promotion. *American Journal of Preventive Medicine, 19*(2), 121-126.

Marcus, B.H., Owen, N., Forsyth, L.H., Cavill, N.A., & Fridinger, F. (1998). Physical activity interventions using mass media, print media, and information technology. *American Journal of Preventive Medicine, 15*(4), 362-378.

Matthews, C.E., Chen, K.Y., Freedson, P.S., Suchowski, M.S., Beech, B.M., Pate, R.R, & Troiano, R.P. (2008). Amount of time spent in sedentary behaviors in the United States, 2003-2004. *American Journal of Epidemiology, 167*(7), 875-881.

Montoye, H.J., Kemper, H.C.G., Saris, W.H.M., & Washburn, R.A. (1996). *Measuring physical activity and energy expenditure.* Champaign, IL: Human Kinetics.

Munro, J.F., Nicholl, J.P., Brazier, J.E., Davey, R., & Cochrane, T. (2004). Cost effectiveness of a community based exercise programme in over 65 year olds: Cluster randomised trial. *Journal of Epidemiology and Community Health, 58*(12), 1004-1010.

Nigg, C.R. (2003). Technology's influence on physical activity and exercise science: The present and the future. *Psychology of Sport and Exercise, 4*(1), 57-65.

Out, J. & Lafreniere, K. (2001). Baby think it over: Using role-play to prevent teen pregnancy. *Adolescence, 36*, 571-582.

Pagliari, C. & Gregor, P. (2004). Literature review of traditional research databases. <www.sdo.lshtm.ac.uk/ehealth.html>.

Plasqui, G. & Weserterp, K.R. (2007). Physical activity assessment with accelerometers: An evaluation against doubly labeled water. *Obesity, 15*(10), 2371-2379.

Porter, D.E., Kirtland, K.A., Neet, M.J., Williams, J.E., & Ainsworth, B.E. (2004). Consideration for using a geographic information system to assess environmental supports for physical activity. *Preventing Chronic Disease: Public Health Research, Practice and Policy, 1*(4), 1-6.

Rennie, K.L., Rowsell, T., Jebb, S.A., Holburn, D., & Wareham, N.J. (2000). A combined heart rate and movement sensor: Proof of concept and preliminary testing study. *European Journal of Clinical Nutrition, 54*(5), 409-414.

Richardson, C.R., Newton, T.L., Abraham, J.J., Sen, A., Jimbo, M., & Swartz, A.M. (2008). A meta-analysis of pedometer-based walking interventions and weight loss. *Annals of Family Medicine, 6*(1), 69-77.

Rimmer, J., Riley, B., Wang, E., & Rauworth, A. (2004). Development and validation of AIMFREE: Accessibility instruments measuring fitness and recreation environments. *Disability and Rehabilitation, 26*(18), 1087-1095.

Rodriguez, D.A., Brown, A.L., & Troped, P.J. (2005). Portable global positioning units to complement accelerometry-based physical activity monitors. *Medicine & Science in Sports & Exercise, 37*(11, Suppl.), 572-581.

Scanaill, C., Ahearne, B., & Lyons, G. (2006). Long-term telemonitoring of mobility trends of elderly people using SMS messaging. *IEEE Transactions on Information Technology in Biomedicine, 10*(2), 412-413.

Schutz, Y. & Herren, R. (2000). Assessment of speed of human locomotion using a differential satellite global positioning system. *Medicine & Science in Sports & Exercise, 32*(3), 642-646.

Sevick, M.A., Napolitano, M.A., Papandonatos, G.D., Gordon, A.J., Reiser, L.M., & Marcus, B.H. (2007). Cost-effectiveness of alternative approaches for motivating activity in sedentary adults: Results of project STRIDE. *Preventive Medicine*, *45*(1), 54-61.

Terrier, P., Ladetto, Q., Merminod, B., & Schutz, Y. (2000). High-precision satellite positioning system as a new tool to study the biomechanics of human locomotion. *Journal of Biomechanics, 33*(12), 1717-1722.

Text messaging. (2008, August 24). In *Wikipedia, the free encyclopedia.* Retrieved August 25, 2008 from http://en.wikipedia.org/wiki/Text_messaging.

Torok, D.J., Duey, W.J., Bassett, Jr., D.R., Howley, E.T., & Mancuso, P. (1995). Cardiovascular response to exercise in sprinters and distance runners. *Medicine & Science in Sports & Exercise, 27*(7), 1050-1056.

Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine & Science in Sports & Exercise, 40*(1), 181-188.

Tudor-Locke, C. (2002). Taking steps toward increase physical activity: Using pedometers to measure and motivate. *Research Digest, 3*(7), 1-8.

Tudor-Locke, C., Hatano, Y., Pangrazi, R.P., & Kang, M. (2008). Revisiting "How many steps are enough?" *Medicine & Science in Sports & Exercise, 40*, 7(Suppl.), 537-543.

U.S. Department of Health and Human Services (2000). *Reducing tobacco use: a report of the surgeon general.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Vandelanotte, C., Spathonis, K.M., Eakin, E.G., & Owen, N. (2007). Website-delivered physical activity interventions: A review of the literature. *American Journal of Preventive Medicine, 33*(1), 54-64.

Welk, G.J. (Ed.) (2002a). *Physical activity assessment for health-related research.* Champaign, IL: Human Kinetics.

Welk, G.J. (2002b). Use of accelerometry-based activity monitors to assess physical activity. In G. Welk (Ed.), *Physical activity assessments for health-related research* (pp. 125-141). Champaign, IL: Human Kinetics.

Wii. (2008, August 24). In *Wikipedia, the free encyclopedia.* Retrieved August 25, 2008 from http://enwikipedia.org/wiki/Wii.

Williams, D.M., Matthews, C.E., Rutt, C., Napolitano, M.A., & Marcus, B.H. (2008). Interventions to increase walking behavior. *Medicine & Science in Sports & Exercise, 40, 7*(Suppl.), 567-573.

Wilmore, J.H., & Haskell, W.L. (1971). Use of the heart rate-energy expenditure relationship in the individualized prescription of exercise. *The American Journal of Clinical Nutrition, 24*(9), 1186-1192.

WVU Today (2007). *Konami's Dance Dance Revolution provides health benefits to children of West Virginia. Retrieved August 25, 2008 from http://wvutoday.wvu.edu/news/page/5213/.*

Yen, Y-W. (2008). YouTube looks for the money clip. Retrieved July 20, 2008 from http://techland.blogs.fortune.cnn.com/2008/03/25/youtube-looks-for-the-money-clip/.

Zhu, W. (2003). Assessing physical activity space: Issues and challenges. *Proceedings II of 2003 Daegu Universiade Conference: Facing the Challenge* (pp. 601-608). Daegu, Korea: 2003 Daegu Universiade Conference Organizing Committee.

Zhu, W., Hasegawa-Johnson, M., Roth, D., Kantor, A., Gao, Y., Gandhi, M.A., Park, Y., & Yang, L. (2006). Validation of an E-diary system for assessing physical activities. *Medicine & Science in Sport & Exercise*, 38(Suppl 5), S102-103.

Zhu, W. (2007). Promoting physical activity through internet: A persuasive technology view. In de Kort, Y., Ijsselsteijn, W., Midden, C., Eggen, B., & Fogg, B.J. (Eds.). *Persuasive technology* (pp. 12-17). New York: Springer.