Patient-Empowerment Interactive Technologies

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Video games capture the rapt attention of an individual player’s mind and body, providing new opportunities for personalized health care. An example of therapeutic interactive technologies is an incentive-based video game that translates physical exercise into mental empowerment via motivational metaphoric visualization in order to help patients psychologically overcome cancer. Such nonpharmacological interventions may enhance patients’ resilience toward various chronic disorders via neuronal mechanisms that activate positive emotions and the reward system.

ARMING THE PATIENT

Individuals affected by chronic diseases frequently experience physical deconditioning, mood disturbances, and diminished quality of life. Such comorbidities further compromise overall health, affecting medical treatments and escalating care costs for chronic diseases. Consider pediatric cancer: Approximately 12,400 children and adolescents are diagnosed annually in the United States. The overall 5-year survival rates for these patients have dramatically improved from an estimated 28% in the 1960s to over 75% currently. This has been achieved largely through the identification of effective combination chemotherapy; cooperative group clinical and translational investigation; and advancements in molecular genetics, radiation therapy surgical techniques, and supportive care. Nevertheless, children diagnosed with cancer are significantly more likely to experience compromised mental health and quality of life as compared with siblings and peers (1). Challenges for these children include fear of death, altered body image and sense of vitality, life-disrupting pain, changes in social support, and repeated medical interventions. Diminished emotional and mental strength and mood disturbances are common (2). Current interventions used for these comorbidities include counseling, physical therapy, and pharmacological therapies. Research suggests that children with a wide range of coping strategies feel more in control and thus experience less anxiety than do those with a narrow range of coping strategies (3). A key feature shared by all of these approaches is that they are externally administered.

A complementary approach to addressing patient depression and fatigue involves the concept of empowerment—an enhanced mental ability to understand and influence one’s own health status. Empowerment stems from access to information and resources that offer a range of options to facilitate informed decisions and can therefore be a major factor in maintaining and improving health. A “fighting spirit,” central to empowerment and resilience, is one’s enduring drive to refuse to surrender to seemingly insurmountable challenges (4–6). An emerging strategy to promote resilience and to enhance one’s sense of empowerment has emerged from none other than video-game technology.

HEALTHY VIDEO GAMES

Health-promoting interactive technologies can provide opportunities for patient self-education toward understanding of symptoms and medications, which in turn promotes improved patient disease management (7). Currently, there are two major categories of health-related interactive games: sedentary and activity-promoting video games (Table 1). Sedentary video games (7–11), such as Packy & Marlon and Re-Mission, focus on educating patients regarding a specific health condition by merging lessons and quizzes with puzzles and plots. In Packy & Marlon, a diabetic patient learns to manage his or her diabetes by maintaining the protagonist’s blood sugar within a healthy range through proper insulin use and diet while playing toward the ultimate goal of saving a summer camp from the destruction of rodents (8). Re-Mission, introduced in 2006 by HopeLab (http://www.hopelab.org), was designed to empower cancer patients by manipulating an on-screen microscopic robot to destroy cancer cells while simultaneously educating patients about cancer and management of chemotherapy-related side effects. Two randomized, multicenter trials have demonstrated efficacy of Re-Mission in educating cancer patients (9) and in improving adherence to chemotherapy treatments (12).

Commercially available activity-promoting video games, or “exergames,” that use gaming console systems, such as Wii (Nintendo) (Fig. 1), Xbox (Microsoft), or PlayStation (Sony), have also been used for clinical purposes (Table 1). For example, although the video game Dance Dance Revolution was not designed specifically to treat childhood obesity, it has been shown to be an effective aerobic workout that promotes weight loss in childhood obesity (7, 13–15). Similarly, Wii Boxing and Bowling games have been effective in neurorehabilitation of adults with Parkinson’s disease (16) and stroke (17, 18). Patients with hemiplegia after stroke can use an action video game Circus Challenge (Limbs Alive Ltd, http://www. limbsalive.com) to help regain control of their arms by performing tasks of increasing difficulty. Limited studies comparing active with passive video games indicate that activity-promoting video games lead to increased energy expenditure when compared with sedentary video games in healthy children (14). Therapeutic applications of existing video games were recently reviewed (19) and are also the subject of discussions at the annual Games for Health conference sponsored by the Robert Wood Johnson Foundation (http://www.gamesforhealth.org).

In light of the existing games, a prototype game of the patient empowerment was recently tested by pediatric cancer patients in Primary Children’s Medical Center, Salt Lake City, Utah (20). The concept of interactive technology directing patient participation at improving one’s own clinically measurable parameters of function was applied...
Table 1. Examples of interactive technologies targeted against chronic diseases.

<table>
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<th>Aim</th>
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<td><strong>Sedentary games</strong></td>
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<td>Bronkie the Brachiosaurus</td>
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<td>Patients showed improved knowledge of and attitude toward asthma and improved communication and self-care behaviors</td>
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<td>Air Academy: The Quest for Airtopia</td>
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<tr>
<td>Re-Mission</td>
<td>Cancer awareness and management</td>
<td>Patients showed increased cancer-related knowledge</td>
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<tr>
<td>Packy &amp; Marlon</td>
<td>Diabetes awareness and management</td>
<td>Patients showed improved patient self-efficacy, communication with parents regarding diabetes, self-care behaviors, and fewer urgent diabetes-related doctor visits</td>
<td>(8)</td>
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<tr>
<td>Squire Quest</td>
<td>Improve eating habits</td>
<td>Players consumed increased servings of fruit, juice, and vegetables</td>
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<td>Wii Fit</td>
<td>Improve balance and mobility in patients with Parkinson’s disease</td>
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In a recent study of 57 healthy undergraduates, fMRI data suggested that the Re-Mission–induced activation of reward-related mesolimbic neural circuits resulted from actively playing video games as opposed to watching content on screen (25). Another area of the brain activated by interactive games is the cingulate gyrus, an area involved in visual-spatial attention and depression (24) and implicated in interactions with the striatum, which is stimulated to release dopamine in interactive-game players (27). To our knowledge, no studies on neurochemical changes in patients playing health-promoting video games have been published to date.

**CHALLENGES, COSTS, AND PROMISES**

From a translational point of view, development of therapeutic interactive technologies requires an approach similar to that used in developing a new pharmaceutical drug. In this respect, various games could be considered as “lead compounds.” To deliver a safe and efficacious interactive video game that is validated for a specific disease, multidisciplinary collaboration among clinicians, patients, psychologists, physical therapists, artists, and video-game developers is crucial. One major challenge in developing therapeutic interactive technologies is timing: The gaming industry moves more rapidly than do the lengthy clinical trials required for new medical therapies. To overcome technological and market challenges for therapeutic video games, synchronization between design and production and the use of fundamental interactive actions and responses will be necessary for migrating to future platforms. However, there are also high initial development costs of therapeutic video games, which can preclude widespread adoption of this approach.

Patient empowerment has been promoted by the World Health Organization as a tool for clinicians to promote health and to manage and prevent disease (28). Such empowerment tools can also be personalized, in which a patient self-administers “adjuvant empowerment therapy” tailored to his or her specific disease, along with appropriate pharmacological treatments. The long-term goals of interactive empowerment technologies are to clinically validate the feasibility, safety, and efficacy in (i) developing resilience and empowerment over one’s disease; (ii) improving disease-related physical and cardiovascular deconditioning, which in turn could mean shorter hospital stays and decreased health-

to create the **Patient Empowerment Exercise Video Game (PE Game)**, which is an activity-promoting, interactive game specifically designed to improve resilience, empowerment, and a fighting spirit in pediatric oncology patients. The key feature of the PE Game design is bridging physical exercise and mental empowerment via positive visualization. Visualization to improve physical function has been beneficial in diverse conditions ranging from healthy subjects (21) and competitive athletes (22) to neurologic recovery after injury (23).

Video games are emerging as attractive technologies to educate and self-empower patients to manage their diseases and accelerate their recovery. Current video games address a broad range of diseases, including cancer and metabolic and neurological disorders. Although early clinical findings on health-promoting video games are promising (24), their effects on therapeutic outcomes have yet to be clinically validated in pivotal dose-response (or rather play-time response) studies that include large sample sizes. Clinical evaluation of daily and total play time, types of game stories and music, and intensity of physical activities will provide useful information for development and optimization of therapeutic exergames.

**YOUR BRAIN ON GAMES**

Interactive health technologies provide distinct investigative opportunities for clinicians and neuroscientists searching for new therapeutic interventions. Functional magnetic resonance imaging (fMRI) of people playing online games and video games has shown increased activity in several brain regions, including the nucleus accumbens (25). This observation is especially important in the context of empowerment because a failure to sustain nucleus accumbens activity upon exposure to positive emotions was reported in patients with major depression (26). The nucleus accumbens and amygdala work in concert to regulate the intensity of emotional responses, with the amygdala functioning in the reduction and the nucleus accumbens functioning in the amplification of cognitive reappraisal success—one mechanism of emotion regulation in which stressors are interpreted in a positive manner.
care costs; and (iii) identifying biomarkers of resilience and empowerment. Video games should be designed for patients of diverse ages and medical conditions, including neurological, cardiovascular, pulmonary, metabolic, and infectious diseases (Table 1). An important aspect of the interactive technologies that favors their future success in health care is the “fun” factor because unlike taking medications, playing therapeutic video games can bring smiles, hopefully improving compliance with other necessary treatments to accelerate healing.

REFERENCES AND NOTES
20. C. Bruggers, in Pediatric Academic Societies (Boston, Massachusetts, 2012).

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Fig. 1. Have fun, get healthy. Video games, such as those played on the Wii, are not only for healthy children or adults. Such interactive technologies have proven to help patients feel mentally empowered and physically fit.
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