Chapter 54
Using Smart Home Technology and Health-Promoting Exercise

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> *The Internet home-based group exercise was great. I got stronger. I have a sense of accomplishment. Now that the program is over, what's next to motivate me to do home-exercise?*
> Participant

Abstract Falls have a very high prevalence in older adults (aged 65 and older) and are probable causes of decreased physical activities, function, and quality of life, as well as increased depression and nursing home placement. Home exercise is an effective way to reduce fall risk factors, but there is often low adherence. The use of smart home technology with health-promoting exercise can be a new method for occupational therapists to reduce fall risks through encouraging an active lifestyle.

Keywords Fall risks · Functional status · Older adults · Smart home · Virtual exercise

Background

One of the major goals for occupational therapists (OTs) in providing services for older adults is to enable them to continue living in their own home, if they so desire (Canadian Association of Occupational Therapists 2011) and being as independent as possible, through promotion of wellness (American Occupational Therapy Association 2013). For this purpose, maintaining their physical as well as cognitive function is of vital importance. One way to achieve this is to improve their home environment by making it *a smart home*. This includes automated lighting and appliance control in addition to a security system through the use of a computer,

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I. Söderback (ed.), *International Handbook of Occupational Therapy Interventions,*
DOI 10.1007/978-3-319-08141-0_54

making their home more secure and safe. In addition, including health promotion technology may contribute more to independent living.

When *smart home technology* using X10 (X10 USA 2010) devices was retrofitted in older homes, older adults who had some functional deficit in daily activities benefitted. They maintained levels of mobility, instrumental activities of daily living (IADL; use of telephone, shopping for groceries and clothes, light housework, medication intake) (Fillenbaum 1988), and cognition. In addition, health-care technology in a smart home environment was broadened (Tomita et al. 2010), which is conducive to encouraging an active, healthy lifestyle. Here, OTs are not only responsible for rehabilitation but are also encouraged to promote wellness in their clients carrying over the effects of occupational therapy. The current use of smart home technology may assist in maintaining older adults' mobility and IADL functions. This active approach improves older person's physical strength through home-based group exercise using *web conference technology*. The inclusion of health-promoting technology into a smart home may contribute to the likelihood of residents' improved health and mobility.

Definitions

A smart home is a house that has highly advanced automatic systems for lighting, temperature control, multimedia, security, window and door operations, and many other functions (Craven 2013). The definition of a smart home may include these types of technology but should have a purpose according to the resident. For older adults (aged 65 and older), the purpose of making a home smart is likely to include independent living. By automating the control of the entire home, including appliances, electronics, and a security system through voice-recognition software, it may be beneficial for people with visual impairment and very frail older adults. Unfortunately, if these systems entice a sedentary lifestyle, we may need a technology to reverse the immobility, that is, a technology to encourage exercise.

Purpose

The purpose of the smart home technology, with virtual exercise intervention, is to prevent or reduce fall risks and promote physical activities to maintain independent living in older adults with a history of falls using cyberspace to provide informational, instrumental, emotional, and appraisal support.

Method

Candidates for the Intervention

Candidates for the intervention are those individuals who need to improve physical strength and mobility through regular exercise, such as those with a history of

falling who are at risk for future falls, diabetes, heart failure, hypertension, hypotension, obesity, or arthritis. Also, those who need to prevent bone density loss and osteoporosis, and/or improve pulmonary function are also candidates (Cleveland Clinic 2013), if and when outdoor activities are difficult to carry out.

Epidemiology

Inclusion criteria for the virtual exercise intervention are an individual (a) aged (>65 years) who needs to do regular exercise or increase mobility, (b) having a history of a fall, (c) ability to use a computer or have someone to help operate a computer, (d) ability to follow exercise instructions, and (e) availability of a fast Internet connection (download speed >30 Mbps).

Settings

The intervention took place in *cyberspace* by health-care professionals connecting with participants via the Internet. Participants exercised in their own homes.

The Role of the OT

The OT functions as a teacher, coach, facilitator, and problem solver, by providing scheduled exercises, answering questions about exercise, keeping track of attendance and following-up for absence, solving technological difficulty, and providing feedback regarding improvement or suggestions for improvement. The OT performs assessments of client's fall risks using questionnaires, a goniometer, and isometric strength measurement equipment. In addition, the OT is actively involved in interprofessional research with nurses, physical therapist (PTs), exercise scientists, exercise physiologists, and physicians.

Results

Clinical Application of the Smart Home Intervention

The intervention requires two types of technology: smart home and web conference.

Smart home technology: For older adults, smart home technology should be inexpensive, reacquire no new writing (or retrofit can be done), relatively simple to install, easy to operate, compatible with many products, and control many lights and appliances. For these reasons, X10 products were used. These products include stand-alone products such as door and window security, chime, flashing light,

Fig. 54.1 Example on a lighting module

emergency response system; products with a remote control operation such as lights and appliance module, and motion sensor that work with a transceiver; and software called ActiveHome to set automatic timing for lighting and appliances.

However, currently, there are other smart home technologies such as INSTEON for wireless home control (INSTEON 2013) using universal power line bus (UPB); based on the X10 concept, Z-Wave, which is a wireless technology that makes a regular house smart (Z-Wave 2013); and ZigBee Home Automation, which offers products that uses ZigBee standard for the technology for smart homes (ZigBee Alliance 2013).

Web Conference Technology For the home exercise intervention, web conference technology is utilized. The free version of ooVoo (ooVoo LLC 2013) was used, which is a proprietary video chat and instant messaging participants. This can connect up to 12 people (Figs. 54.1 and 54.2).

Technical Problems Clients encountered some problems when using the smart home technology: (a) motion sensors were too sensitive, as well as not compatible with fluoresced lights; therefore, a wide tape on one side of motion detector

Fig. 54.2 Home exercise using screen ooVoo

was used or moved to another wall, (b) a 5-in-1 remote control stopped working, even with changing the batteries; therefore, a key chain remote was utilized, (c) radio interference was found when the light timer was on; therefore, the code was changed, suspecting other X10 sources inside the home were interfering with the signal, (d) door chime went off in the case of a power outage and resetting chime solved the problem, and (e) if lights were turned off manually, the technology stops working. To resume the scheduled time, the lights should be turned on manually, and then turned off using the X10 program to make it work. Further, old houses and apartment have old phone lines and electricity lines that may interfere with the use of the technology. The solution was to use a filter, a simple plug called SignaLink (Signalink Technologies Inc. 2013), to block noise on the power line. Although OTs needed to intervene to solve each problem, the knowledge was transferred to clients and most of them learned how to manage the smart home technology.

A problem occurred during the exercise session period when Windows or other software updates started and as a result, clients could not join the ooVoo chat room. The solution was to add ooVoo.com to the compatibility setting in Internet Explorer. The clients were encouraged to upgrade software during the intervention period. Clients could participate in the exercise session 100 % of the time using the Internet, even when they traveled away from home in the USA.

Implementing the Smart Home Technology The first step is to decide which smart home automatic features are suitable for a client. Then, load the ActiveHome into the computer and download necessary updates. The PC interface connects a computer via a universal serial bus (USB) cable and sends start and stop instructions to modules through the existing home's wiring. Dials on the lighting and other modules are set using a screwdriver to have its own alphanumeric code, with a choice of 256 combinations. The schedules work, even when a PC is turned off. The PC can catch radio frequency commands from the universal and key chain remotes via the antenna. Online remote connection is now available, if necessary. After testing and checking the battery in the interface device, instruction on how to use smart home technology needs to be done, taking about 30 min. Finally, clients' perception of the use of smart home technology was very positive. Of 50 clients, who participated in the intervention, 87.3 % of them found this technology very useful, and 67.6 % found overall operation of the technology easy. About 80 % of them said they recommend its use to elderly people (27 %) and anyone (53 %; Tomita et al. 2010).

The Exercise Sessions Just before the scheduled exercise time, clients "call in" the chat room to join the session. The monitoring station accepts them as they join the chat room, and they appear on the monitoring screen. The technology is available free of charge, if clients have a dual-core computer and fast Internet connection. Participants are a closed group, and clients can view and talk to all people present on the screen. When the exercise begins, participants enlarge the exercise instructor window for easier viewing. While they are exercising, following the premade instruction video, OTs monitor their safety and correct movements. The exercise

can include progressive strengthening and balance exercise, using a standard (18 in.) sturdy chair, TheraBand® with increasing strength, and ankle weighs with increasing weight.

If participants cannot participate in an exercise session, a YouTube link for the week can be made available through e-mail to make up the missed session. Evaluations or feedback of their improvement are important aspects to motivate and increase self-efficacy for exercise.

Evidence-Based Practice

Morris et al. (2012) showed, in a systematic review using a qualitative assessment, that a wide range of smart technologies are available to assist older people to live well at home in the community. However, the authors concluded that the specific evidence for the effectiveness of using smart home technology as a method to promote a healthy and active life is sparsely documented. The study by Tomita et al. (2010) is currently the only study using a randomized controlled trial (RCT). The differences between the two groups were significant. The contributing factor for maintaining (a) cognitive function was the use of the computer to operate the smart home system, e-mail with friends and relatives, connect with the world through Internet sites and play computer games and (b) their mobility level was automated lighting and security systems that kept them safe and active inside their home, maintaining their physical strength. In other words, the participants were not affected by the process of aging in terms of mobility and cognitive function. In contrast, age-equivalent older adults who did not use smart home technology declined in these areas. The gains sustained for 2 years. (Tomita et al. 2006, 2007).

Discussion

Merits of using smart home technology included an increased sense of security from alarms attached to windows and doors and automatic turn on and off feature for lightning and appliances, which help older adults feel independent and, at the same time, improves mobility. The use of web conference technology that enables home exercise was successful in achieving 100 % attendance. This is a way to bring OT to the home environment utilizing a smart home. Because of the convenience of staying home and having close contact with an OT, it is expected that clients will adhere to the therapy, which will likely bring about positive OT results. Technology advancements are useful for people of all ages, including older adults. However, OTs' knowledge about smart home technology needs to be broadened for possible incorporation in OT interventions.

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The Case Study of Rita: Use of Smart Home Technology to Promote a Healthy and Active Lifestyle

Keywords Mobility, physical strength, smart home technology

Introduction

The theme of this case study concerns the use of smart home technology by older adults to maintain independence through adopting a healthy and active lifestyle.

The student's tasks include the following:

- Understanding how home improvement solutions should be planned.
- Finding information on studies using smart home technology.
- Describing the current status of smart homes for older adults.
- Identifying key factors to maintain older adults' independence.
- Synthesizing the information into a report.

As a starting point, students should use the following references to gather background information. Important references are as follows:

1. Christenson M, Lorentzen L (2011) Proposing solutions. In: Christenson M, Chase C (eds) Occupational therapy and home modification. The American Occupation Theory Association, Inc., Bethesda, MD
2. Morris ME, Adair B, Miller K, Ozanne E, Hansen R, Pearce AJ, Santamaria N et al (2013) Using smart-home technologies to assist older people to live well at home. Home technology for mobility exercising. J Aging Sci 1(101):1–9
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4. National Institute on Aging & World Health Organization (2011) Global health and aging. http://www.who.int/ageing/publications/global_health.pdf
5. Tomita M, Russ L, Sridhar R, Naughton B (2010) Smart home with healthcare technologies for community-dwelling older adults. Smart home systems, pp 139–158, IN-TECH, Vienna

Overview of the Content

Major Goals of the Actual Intervention

The major goals of using smart home technology are (1) maximization of independence, (2) prevention of reduced physical strength, (3) promotion of a healthy and active lifestyle, and (4) improvement in the frequency of regular exercise.

Learning Objectives

By the end of studying this chapter, the learner will be able to:

- Identify common home environmental problems and make recommendations for improvement.
- Understand the process of using smart home technology to promote health and an active lifestyle.
- Use information from the literature and clinical reasoning to develop an intervention plan for the specific case study and similar clinical situations.

The Background History of Clinical Case Study

Personal Information

Rita (pseudonym) is a 90-year-old woman. Her present height is 147 cm (about 4′11″) and her weight is 54 kg (about 119 lbs). She is a widow and lives alone in a senior town house she owns in the suburbs. She communicates with her family over long distance using online Skype once a week. She still drives a car to go to a nearby church 7 days a week.

Medical Information Including Prognoses

Rita is relatively healthy with a few physical conditions, including thyroid symptoms, minor chronic obstructive pulmonary disease, and osteoarthritis in her knees, as well as scoliosis. Rita takes four medications, one of which is to improve her cognition. She had a left hip replacement 3 years ago. Her blood pressure and cholesterol levels are within normal limits. She reported she is very satisfied with her life. A month ago, Rita had a fall in her attached garage and hit her head. She was unconscious for several minutes, but got up and drove to church. She did not have any recollection of these events. Noticing her disheveled appearance and blood on her face, church members took her to the emergency room of a nearby hospital. Rita stayed in the hospital for 3 days for tests, but no abnormality was detected. Her primary care physician encouraged her to begin the exercise program slowly.

Occupational Therapy Interventions

Rita's home environment needed change in increase safety to exercise. An OT completed a home assessment and recommended a number of home modifications

and environmental interventions, and provided needed smart home technology for promoting the exercise program.

Home modifications were (a) to clear clutter in the garage, especially the path from the driver side of Rita's car to the entrance door into her kitchen; (b) to secure the loose railing leading up the steps to the door from the garage; (c) to automate the lighting in the garage ceiling using X10 technology and providing a remote control; (d) to install a motion sensor LED night light to the lower side of the garage wall and the hallway; (e) to use a simple version of the automation system (MT13 MiniTimer); and (f) to add a timed schedule to (1) turn a porch light on at dusk and off at 6:30 a.m., (2) turn off the basement light at night, (3) sound a medication alert time using an alarm clock, and (4) start brewing coffee at 7:15 a.m.

Rita participated in the web conference exercise program during the 6 months. She joined the chat room before anyone else, talked with an OT about her health, and asked about exercise procedures and computer operation. She missed 5 out of 72 sessions because she visited her family out of state for her 90th birthday. When she traveled within the state, she carried the laptop and joined the session. As the progressive exercise advanced, she used ankle weights and shoeboxes for exercise as required. The OT decided not to recommend the use of a TheraBand® because it required postural stability.

Positive effects were noted for lower extremity strength, grip strength, level of physical activity, fear of falling, functional independence, and completion of IADL tasks. Now the study is over, a friend reported that Rita misses the exercise session. It seems home exercise was a just the right amount of activity that she needed to maintain her independence, physically and cognitively.

The Student's Report

The following guiding questions have been identified in developing possible solutions to Rita. These questions were generated from the references found in the literature search:

1. What are the major concepts used in the case?
2. What assessments can be used for home evaluations?
3. What is the research-based evidence on the impact of physical activity on function?
4. What assessments can be used to measure Rita's function and performance?
5. What home modifications could be made by the OT to promote safety and fall prevention?
6. What is needed for Rita to participate in the online exercise program?
7. What are some long-term goals for Rita?
8. What could the OT do to help Rita maintain her exercise program?