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Finger Dexterity Exercise For Older Adults- Transforming Older Adults' Hands Exercise Experience With Physical Tools And Technology

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Abstract

Transforming finger dexterity exercises involved filming and analyzing older adults' hand movements in an independent living facility located in Syracuse, New York. Hands help people complete the movements during the activities of daily living (ADLs) and the instrumental activities of daily living (IADLs). Hand function is crucial for seniors to sustain their capacity for independent living. Independence can be preserved if seniors are able to move their fingers freely to perform personal tasks. For my study design, I used existing foam balls as props to enhance the older adults' exercise routines. The exercise experience was examined through prototypes, tests, and interviews to identify the functions of the props as exercise tools. The findings suggest that a physical tool can aid seniors in enhancing their finger dexterity and hand functions. An instruction book and exercise products were designed as an exercise system called "Positive Ball" to allow older adults to effectively maintain their finger dexterity. The PB Exercise System is aimed at developing the hand strength and finger dexterity of seniors. Improving their upper body strength via this exercise routine mitigates one of the risk factors for deteriorating physical well-being.

FINGER DEXTERITY EXERCISE FOR OLDER ADULTS: TRANSFORMING OLDER ADULTS' HAND EXERCISE EXPERIENCE WITH PHYSICAL TOOLS AND TECHNOLOGY

By

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Problem Statement

Exercise plays an important role in healthy daily lives. Brassington et al. noted the following:

> Over the past 40 years, researchers from a variety of academic disciplines (e.g., public health, exercise science, and psychology) have provided data on the powerful positive effects of physical activity on every system in the human body (e.g., cardiovascular, respiratory, immune, and muscular) and the detrimental health effects of inactivity. (Brassington 353)

Exercise helps older adults prolong their ability to function independently because it maintains the health of their bones and muscles.

> Regular exercise, specifically weight-bearing impact exercise and PRT, and adequate nutrition, particularly with regard to dietary calcium, vitamin D, and protein, are commonly pre- scribed for the prevention and management of osteoporosis, sarcopenia, falls, and fractures. (Daly 224)

Based on the interview with Karen Giblin (the activity manager in Maple Downs facility in Syracuse, NY), and Anne Whitaker (the occupational therapist in Menorah Park facility in Syracuse, NY), the concept of constant exercise is already established in those facilities that provide services and care for older adults such as independent living and assisted living centers.

Finger functions are an essential part of all human capabilities and are very significant in the maintenance of personal wellness. The weakness and poor dexterity of older adults' fingers make their daily lives very difficult. Ranganathan et al. provided data to prove this problem: "Elderly individuals face increased difficultly in performing daily living tasks such

as tying shoe laces, fastening buttons, or writing a note. Their hand sensation and ability to control finger force are significantly reduced" (Ranganathan et al. M518). Life becomes difficult for older adults when their finger functions begin to decline. Such difficulty prevents them from maintaining their independence in performing tasks such as feeding themselves or completing their daily routine with high quality. During the interviews in Maple Down's dance class, some participants suggested that the deterioration of the hand functions of the residents of independent or assisted facilities might be caused by the insignificance of their hand manipulation habits. Older adults simply do not need to manipulate their hands as regularly as they did when they were younger; their hand functions may be limited to eating their meals and brushing their teeth.

Dance classes offer opportunities for older adults to practice the dexterity of their fingers. The present research was based on a dancing class called NIA in an independent living facility located in Syracuse, NY. A design opportunity was found on the video recording of the body movements of the older adults in this class. This dance class moves and flexes people's bodies and includes finger exercises for dexterity. However, the older adults tended to ignore small finger movements in favor of whole body movements which they perform sufficiently well. Given that they basically held nothing in their hands except air, these seniors have little natural inclination to use their hands. The residents who always participated in the dance class already developed the habit of engaging in continuous exercise in their daily life. However, their awareness of the importance of flexing their fingers needed to be increased before hand functionality was lost.

The solution that I have proposed with my design is the Positive Ball (PB) Exercise System, which consists of the physical tools, an instruction book, and an instruction video. The tools can also be used with applications on smartphones and central information systems.

This tool can be integrated into an existing exercise class or used alone. This system includes pinching, grabbing, rubbing, and lifting a ball with dance movements to strengthen their hands. “The finger pinch task, however, is used for almost all types of manipulations each day. It can be considered as a highly “trained” task that may allow limited room for training-induced improvements” (Ranganathan et al. M521). A sensor is placed in the PB collects movement data on hand exercises. This information can be shared among the seniors in the facility to promote their accomplishments and keep them engaged. The addition of the balls in their dance routine allows them to experience a new sensation in their hands. Cooperating with the dance instructor is an efficient strategy to introduce the tool to the residents of the facility. This design can maintain and even improve the older adults’ hand functions with significant effectiveness. “The skilled finger exercise enable elderly subjects to more precisely control their finger pinch, reflected by a steadier pinch force and precision-pinch posture” (Ranganathan et al. M521). Those small motors, such as pinching and squeezing, could help with elders doing the daily activities such as holding a fork and cup which make them have more independent lives.

Literature Review

Aging hand

The aging of the hands is a general issue faced by adults as they grow older. Carmeli, Patish, and Coleman discussed hand aging in their article:

> Hand function decreases with age in both men and women, especially after the age of 65 years. A review is presented of anatomical and physiological changes in the aging hand. The age-related changes in prehension patterns (grip and pinch strength) and hand dexterity in the elderly population are

> considered. Deterioration in hand function in the elderly population is, to a large degree, secondary to age-related degenerative changes in the musculoskeletal, vascular, and nervous systems. Deterioration of hand function in elderly adults is a combination of local structural changes (joints, muscle, tendon, bone, nerve and receptors, blood supply, skin, and fingernails) and more distant changes in neural control. These age-related changes are often accompanied by underlying pathological conditions (osteoporosis, osteoarthritis, rheumatic arthritis, and Parkinson's disease) that are common in the elderly population. (Carmeli, Patish, and Coleman 146)

The hand serves an important function by helping people perform their daily activities; it is also a major sensory tactile organ that transforms information and emotion without verbal communication. The hands are the most active part of people's extremities. Thus, many factors affect hand function for the elderly; these factors include age-related diseases, such as osteoarthritis.

> Common metabolic and skeletal diseases in elderly adults, such as osteoarthritis, rheumatoid arthritis, and osteoporosis, and hormonal changes are important factors in impaired hand function. Malnutrition may also be a contributory factor in elderly adults and may involve an imbalance in homeostasis of minerals, in particular disturbances in calcium metabolism, or a lack of specific nutritional factors. (Carmeli, Patish, and Coleman 146)

The decline of older adults' hand skills may also be caused by their behaviors. Carmeli, Patish, and Coleman indicated that the behaviors of the elderly, "such as declining physical activity, reduced exercise levels, and sedentary lifestyles, may also contribute to impaired

hand function" (Carmeli, Patish, and Coleman 146). Carmeli, Patish, and Coleman's study shows that the decline of hand skills by aging is a common issue that seniors face. "After 60 years of age, there is a rapid decline in hand-grip strength, by as much as 20-25%" (Carmeli, Patish, and Coleman 147). Maintaining older adults' hand functions and slowing down the loss of their hand skills loss are significant issues that are worth investigating. (Carmeli, Patish, and Coleman 146)

Importance of hand strength for older adults

The article "Hand-grip strength predicts incident disability in non-disabled older men" aims to demonstrate the importance of maintaining hand strength for seniors. According to the paper, "The reduction of muscular strength and power which is often associated with ageing may be one of the links between reduced physical performance and functional decline" (Giampaoli et al. 283). In the present research, I explore the promotion of seniors' hand functions via the PB Exercise System.

"Hand-grip performance in older men is a predictor of disability" (Giampaoli et al. 283). In this work, the following concepts were first presented: the activities of daily living (ADLs) and the instrumental activities of daily living (IADLs). Examples of ADLs are moving outdoors, climbing stairs, and walking at least 400 m. Examples of IADLs are cooking and doing light or heavy housework. The performance of ADLs and IADLs was classified into four categories: "without any difficulty, with difficulty but without help, some help needed, and unable to perform" (Giampaoli et al. 283–284). The most frequent daily actions performed by hand are grasping, pinching, and tapping, as well as other complicated tasks, such as playing the piano, which requires some fingers to move more than others

(Schieber and Santello 2293). Hand strength was measured by a hand-grip test using a Martin dynamometer in kilopascals. The influence of hand grip was evaluated along with other risk factors by comparing the performance of those daily physical activities and correlating it with hand strength. Other health information, such as health history, heart rate, and blood pressure, was recorded to provide a comprehensive analysis.

Using a sample of 422 participating seniors, the authors cross-sectionally associated hand grip strength with the severity of disability. Among all the risk factors, hand strength is one of the factors that significantly influence older adults' daily lives. Through the monitoring and measuring of ADLs and IADLs, the authors found that strong hand strength prevents physical disability and that poor upper body strength is one of the risk factors for reduced personal independence for seniors.

The PB Exercise System enhances not only hand grip but also finger dexterity. A soft material, such as a foam ball, can be a good start for seniors at any strength level.

Finger exercises

> These can use very simple equipment such as squeezable rubber balls, or elastic bands on fingers. Such exercises should be designed to strengthen grip and maintain joint flexibility of fingers and the wrist. The biological axiom of "use it or lose it" applies to hand function, as it does to any other part of the musculoskeletal system in the body. The proof of such advice can probably be deduced from many great pianists and violinists, whose manual dexterity was retained into ripe old age, presumably as a result of regular hand exercise. (Carmeli, Patish, and Coleman 150)

The article “Skilled Finger Movement Exercise Improves Hand Function,” written by Ranganathan et al., demonstrates the benefits of adopting the Baoding balls to promote grip strength and maximum pinch force for seniors. Identifying the importance of enhanced hand function and developing adequate equipment to help older adults maintain finger dexterity and hand strength are two of the most important tasks for Ranganathan’s finger improvement research work. The usage of a Baoding balls are quite familiar to me given my Chinese heritage. From a very young age, I was told that baoding balls were part of the exercise routine of my grandparents. The article provides a professional analysis of this ball’s effective use for skilled finger movement, which motivates me to adopt such tool as part of the design.

As previously discussed, grip and pinch strength play a crucial role in maintaining the independence of seniors. The study is about using two metal balls to do finger exercise for older adults. Ranganathan et al. assumed that “with a training regimen that provides adequate stimulus to the sensorimotor system it is possible to improve age-related regression in motor function, including manual function, in older adults” (M518). “Human manual function is largely reflected by skillful use of fingers in grasping, lifting, and manipulating objects between the pulps of thumb and one of the four fingers” (Ranganathan et al. M518). Thus, the author conducted an experiment on 28 right-handed volunteers. The volunteers of the experiment were asked to “hold two metal balls in the dominant hand” and then “rotate the balls smoothly clockwise or counterclockwise” (Ranganathan et al. M518). The volunteers performed the procedure as a daily skilled hand exercise routine. After a period of exercise, the experiment measured several aspects of hand function, including hand grip strength, maximum pinch force, hand steadiness, Hoffman reflex, and so on.

The results indicated that the Baoding balls exercise positively influences seniors’ hand function. Although hand grip strength and maximum pinching force did not change

significantly, pinch force steadiness and hand steadiness improved significantly. The training caused a clear improvement in the older people's hand capability. The result of this experiment is important because the Baoding balls are the efficient solution for hand strength in terms of cost and logistics as they do not require large equipment.

Thus, the article emphasized the Baoding balls as a skilled exercise that is very beneficial for manual functions. Hand steadiness and pinch force steadiness can prevent many poor physical operations, such as dropping glasses, silverware, and so on. Improved hand steadiness and finger pinch results in positive changes in motion control in daily life. Thus, adopting the Baoding balls in my design is appropriate.

Technology helps older adults transform their exercise experience

The article "CAMMInA: a mobile ambient information system to motivate elders to exercise" describes the beneficial aspects of a well-designed technology-driven exercise system.

> Several strategies have been identified for designing effective persuasive technology that encourages people to adopt heathy lifestyle habits. However, to implement these strategies for motivating elders to exercise, we need to take into account the elders' particular characteristics, their needs, and the problems they face to exercise. (Rodriguez et al. 1127)

Through analyzing the data obtained from the 40-minute interviews with ten female and non-frail adults, ranging in age from 55 to 77 years old, the interviews attempted to address the problem of identifying the factors that motivate elders to exercise so as to develop an effective strategy to encourage seniors to adopt a healthy lifestyle. In the article, Rodriguez et

al. developed a method with design strategies to evaluate and improve existing persuasive technologies; specifically, the study designed an ambient information system (AIS) to help achieve this goal. AIS analyzed the results of the four adopted strategies and provided suggestions to improve motivation strategies for older adults.

Those strategies include abstraction: “The effectiveness of person displays that provide abstract representations based on metaphors to increase the users consciousness about the impact of adopting healthy habits” (Rodriguez et al. 1130). Trigger the physical activity: “A trigger is defined as an alert that should be presented to users at a moment when they can perform the behavior” (Rodriguez et al. 1130). This alert promotes desirable behavior by including motivational elements. Historical information and reflection: “Persuasive technology should be designed to help the individual to remain focused on his commitment with awareness of his past behavior as it relates to his goals” (historical information); “providing representations of the progress of their short-term goals ensures sustainable exercise and improves persons’ perceived efficacy of the activity” (Reflection) (Rodriguez et al. 1130). Positive and playful reinforcement: “If users perform the desired behavior, they should be rewarded” (Rodriguez et al. 1130).

The researchers in the AIS experiment applied several abstract concepts and developed a method to execute them appropriately. This experiment identified the factors that influence older adults’ motivation to exercise and some strategies to motivate them to conduct physical activities regularly. When designing the PB Exercise System, I took several strategies into account. These strategies and implementation methods should be considered before designing this technology for seniors.

Methodology

Research Probe 1

According the initial concept idea about designing a wearable device to transform older adults' exercise experience, a persona is created on the basis of how technology might improve and associate seniors' daily life to consider the opportunities to combine technology with their routine exercise. The persona's story includes her basic personal information, such as name, age, and habits. The character is named Elizabeth; she uses devices such as a smartphone and an iPad. The story first describes how Elizabeth uses technology to communicate with her friends and how her friends introduced her to the dance program in Syracuse. Then, the story describes instructions on how she can use the wearable device during exercise (see fig. 1).

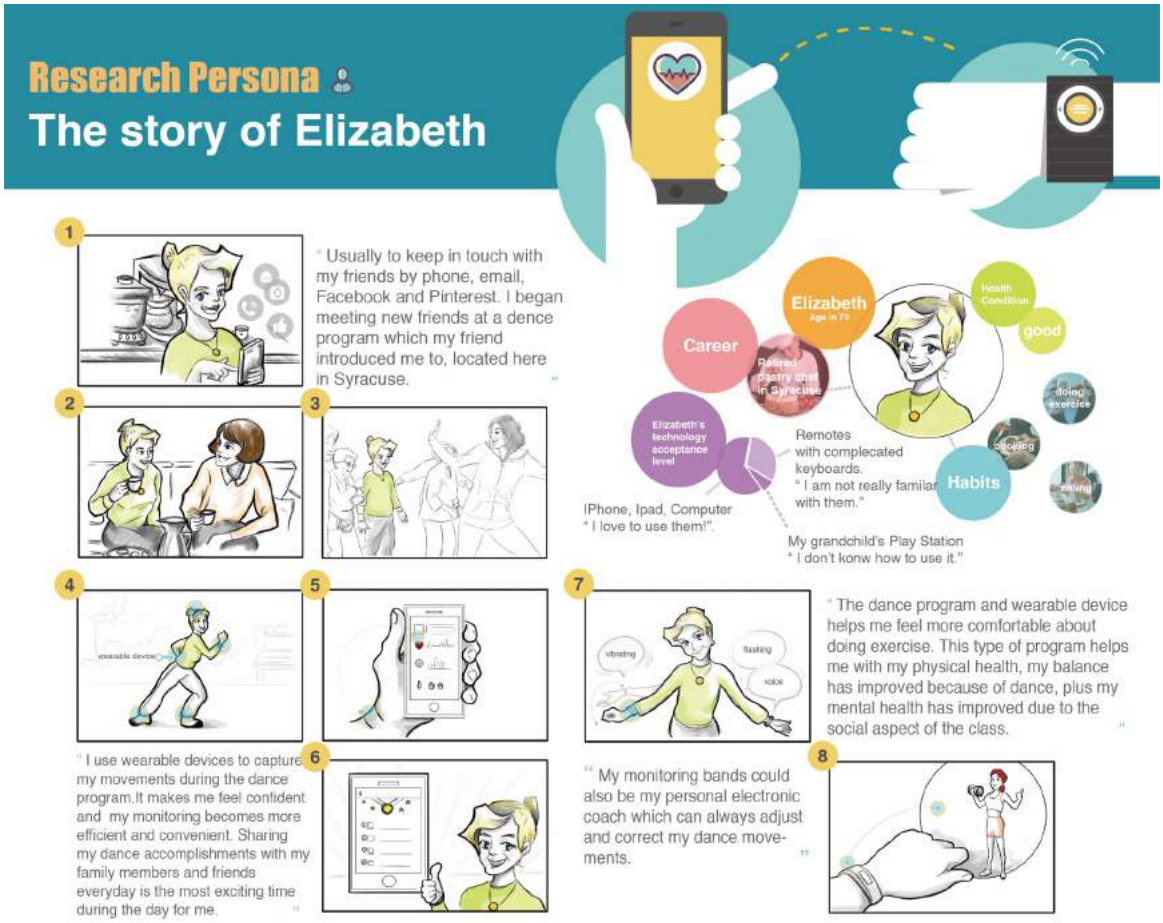

Fig. 1. Persona's storyboard to introduce Elizabeth's daily exercise experience with the wearable device technology.

The target users are older adults from independent living facilities. Thus, before visiting a specific facility, I consider the space in terms of the benefits brought about by technology for seniors' exercise and daily life based on my research. Barbara Dopyera Daley (Guest lecturer, Graduate Design Thesis Class, Syracuse University MFA in Collaborative Design) offered a contact reference from the Nia Now Program in Syracuse, NY.

> Nia is a sensory-based movement lifestyle that leads to health, wellness and fitness. It empowers people of all shapes and sizes by connecting the body, mind, emotions and spirit. Classes are taken barefoot to soul-stirring music in more than 45 countries worldwide. ("General Nia FAQ")

Ellin Adams is 75 years old, and she is the Yoga and Nia Instructor at Teaching Yoga And Nia in Fayetteville and Manlius, NY. She took charge of the dance class in an independent living facility located in Syracuse called Maple Downs. Their class was called "Chair Nia" because every senior who participated in the class went through the whole dance session sitting on a chair; this method prevented these participants from falling during dancing. Yoga and dance are two main exercise methods in "Chair Nia" class; yoga could enhance people's physical and mental health, and also help with people's finger dexterity. In the article " Finger dexterity and visual discrimination following two yoga breathing practices," Telles et al. used two groups of people who had enrolled for stress management. High frequency yoga breathing (kapalabhati, breath rate 1.0 Hz) and breath awareness were practiced by those two groups separately using O'Connor nger dexterity task and a shape and size discrimination

task to analyze people's finger dexterity's improvement. In this case study, Telles et al. assumed that "both kapalabhati and breath awareness improved fine motor skills measured by finger dexterity and visual discrimination assessed by the shape and size discrimination task." which means it is useful to do yoga for seniors during Nia dance class.

In order to learn people's needs better, a questionnaire was prepared for the interview with Ellin and seven residents in Maple Downs who participated in Ellin's Nia dance class. The questions explored personal basic information, such as age, gender, and career. Other questions sought information about how older adults view technology together with doing exercise. The questions are as follows:

1. Have you ever been in an exercise (dance) program before?

2. When you first heard about "these dance classes," what did you think they were?

3. How could wearable technology such as a Fitbit, how people while they exercise?

4. If you could use any form of wearable device, what function might motivate you to keep using it?

Before conducting interviews with the Nia participants in Maple Downs, I presented my basic idea and the persona story to those residents in Nia dance class. I received positive feedback from people and this feedback indicated the effectiveness of the diagrams to explain the purpose of my design. Questionnaires were collected as part of the interviews and the average age of the interviewees was 78. The following are some of the reasons why the interviewees preferred participating in dance exercises. Some of them felt that it improves their cognitive abilities and helps them improve their balance and strength. They also

believed that joining a dance class is a good social method to communicate with other residents in an independent living facility. Ellin and five other residents had participated in other dancing programs as instructors when they were younger. They gave positive feedback about using the PB Exercise System during dance class; they believed that recording their activities could provide them with both information and motivation. Two of the interviewees, including Ellin, were using wearable devices already and the others also wished to try it. Two residents faced difficulties in using smartphones because the screen and the application's user interface design was too small to use easily, therefore they used iPads with bigger screens instead.

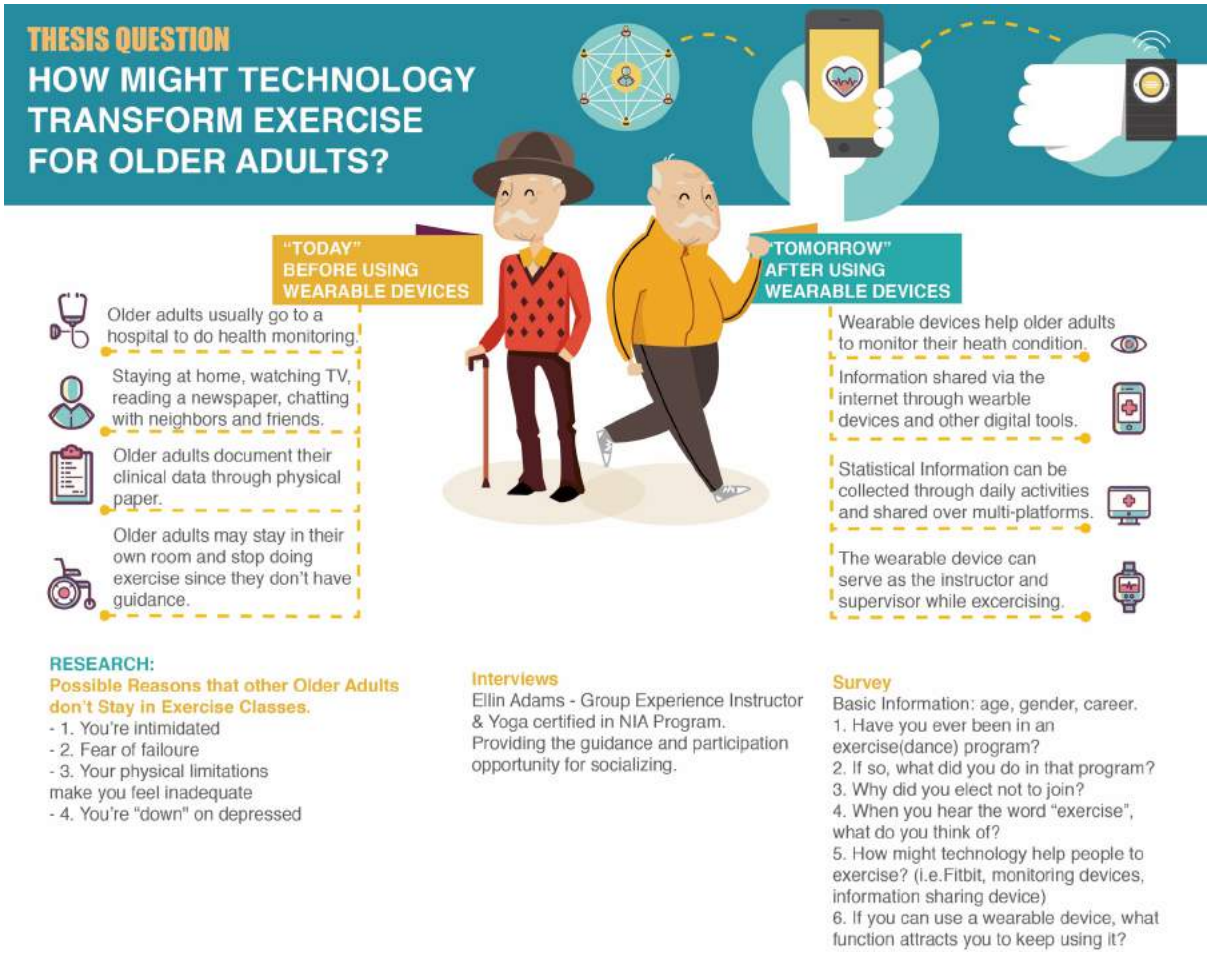

Fig. 2. Poster showing how technology can transform exercise experience for older adults.

Information was collected and shared in the ASI Brown Bag Lunch Series for our Collaborative Design Thesis Investigations on February 12, 2016. I made the Brown Bag Lunch's posters simple and easy to understand by combining visual and literal elements on my maps. Clear icons and diagrams explained my thesis research process and presented the information collected from my interviewees. The first map compared "Today" and "Tomorrow" sections to provide people with a clear view of the older adults' life experiences and the transformation caused by the wearable devices (see fig. 2). Feedback was provided on the posters; adding more references to support my information and providing additional evidence to make the proposal powerful and compelling for the public were recommended. Another poster showed the storyboard about the character "Elizabeth." Elizabeth's experiences (see fig. 1) resonated with people's experiences, as well as that of their family and friends. Using posters to describe research and design ideas was highly efficient for information sharing during the Brown Bag Lunch conversation.

During the Brown Bag meeting, my thesis and design to improve the experience of older adults' exercise received a lot of input. A feedback board helped to collect suggestions and insights efficiently. The feedback provided me with additional direction and ideas for the next step in the research.

The feedback directly provided perspectives on motivation ideas that people are interested in. For instance, they were excited about the possibility of using wearable devices that have a personal coach function. This function could make people feel comfortable and confident to do sports. Suggestions on exercise products also helped to complete my design plans. Examples of this feedback included improving the battery problem, adding reminder

alerts in public, and organizing different types of exercises automatically to make the operation simple and convenient.

Research Probe 2

In Probe 2, the research objective was to learn the basic function of wearable devices in the current market and focus on sensors used by those devices. Two popular brands were investigated in Probe 2: Fitbit and Jawbone UP4. The widely used sensor is the accelerometer (see fig. 3).

Fig. 3. Research comparison between main stream trackers.

The initial design concept had wearable devices located in four to six different positions of a person's body to provide instructions during the dancing process. Lights and sounds serve as reminders when people perform nonstandard actions. The device captures the user's movements during dancing or other activities to guide the user's movements and

ensure the correctness of these movements; this function can be achieved by placing several sensors on a person's body. A set of six units can accomplish the function satisfactorily. Two main control units are placed on the wrist. The other four units are attached to the waist and legs (see fig. 4).The sensor contains an accelerometer to capture the speed and direction of the movement and the relative position of all the sensors. The main control unit can identify what type of movement is currently being performed. The system records the information provided by the sensor network and matches the pattern with the database. The recorded movement information is compared with the correct moves stored in the database. Then, the two control units calibrate, and red lights are flashed if the current move is incorrect.

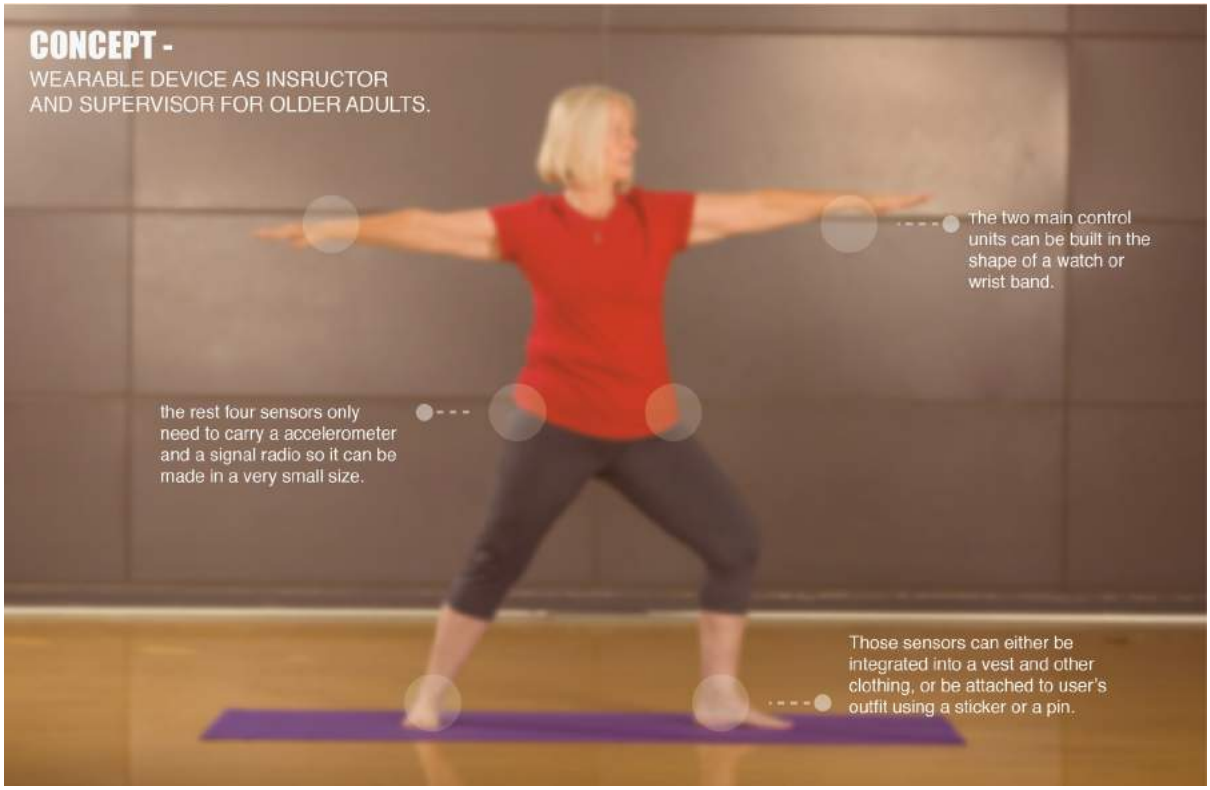

Fig. 4. Initial concept design of the wearable device as a personal electronic exercise instructor.

Research Probe 3

To learn the needs of some older adults, I went to Maple Downs each week and joined their Nia dance class to experience their physical output. After sharing initial ideas with the residents and dance instructor, I received positive feedback from the people who looked forward to using the technology to assist their exercise during and after the dance class. However, the concern was that this design was still in the concept stage and would require time for development. After these conversations with residents, I did not want people to anticipate being able to use this future technology and yet have nothing at present, rather, I wanted to design a product to improve their exercises immediately.

I recorded the seniors' dance movements on video to analyze their movements and emotions. According to Maple Downs' policy, a release form had to be signed by the residents for me to obtain permission to use their images for my design. The release form included consent to film or record and it explained how their input would help my research efforts and improve their exercise experience. I used to think about needs of seniors in Maple Downs according to common issues in daily lives and literature research, however, a design opportunity presented itself when the residents were signing the release form. Four residents in the dance group had difficulties holding the pen; they told me that they did not always write with their hand and that they had hand strength issues. Therefore, they had difficulties writing by hand (see fig. 5).

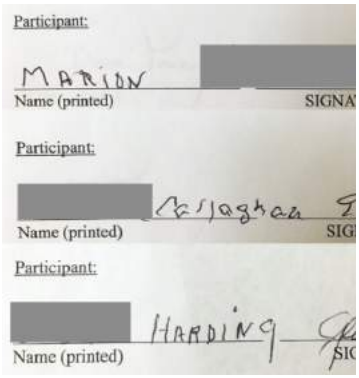

Fig. 5. Signatures from the residents who had handwriting difficulties.

This phenomenon revealed the decline of these participants' hand skills, and this decline clearly affects basic daily activities. "It is clear that common tasks involving precision dexterity, two- hand coordination, such as are needed to thread needles, open buttons on clothing, or fine-grip tasks as in holding a pen or cutlery, become increasingly difficult with aging" (Carmeli, Patish, and Coleman 149).

After observing the dance movements during the class, the instructor from the NIA program also mentioned finger exercises, such as gripping and pushing. These exercises were combined with other body movements. "With aging, performance on a large number of cognitive tasks declines" (Verhaeghen et al. 443). Many older adults in that class neglected the hand movement part (see fig. 6). This problem provided me with a design idea to help older adults concentrate on hand exercises. "The quality of performance in daily living skills, work-related functioning, and recreational activities is determined to a large degree by hand function and manual dexterity" (Carmeli, Patish, and Coleman 146).

Fig. 6. Participants' lack finger exercise since residents may ignore the those type of small movements during dancing as observed.

A FaceTime conversation with my grandfather in China provided design inspiration. He is 76 years old with excellent hand function. During our conversation, he informed me that some older adults in China use Baoding balls (see fig. 7) to rehabilitate hand function after cerebral thrombosis, which causes headache, face and limbs' weakness on one side of the body. Baoding balls are commonly recognized by Chinese people as an efficient tool for exercise; in China are also known as Chinese health balls. Baoding balls are believed to have originated from a small town in Hebei province, China, named Baoding. Baoding balls are quite useful for exercise and meditation and are also beneficial as a form of assistance for medical reasons, such as relieving arthritis in the hands. To use them, two Baoding balls are placed within one palm and are then rotated clockwise and counterclockwise. "Chinese Health Balls are easy to use, and don't require any physical prowess" (Williams 11). Different objectives can be set while exercising with Baoding balls. For example, the user can

avoid touching one ball with the other one by carefully controlling the balls. Using Baoding balls in a flexible way can help users exercise muscles in different parts of the hand.

> When Chinese Health Balls were used in ancient China, it was discovered that exercising with the health balls as part of meditation could also be helpful in achieving a physical and spiritual balance— a healthy life…When you are working with Chinese Health Balls, you are not only exercising the muscles in your hands; you are also sending impulse throughout your entire body. (Williams 14-29)

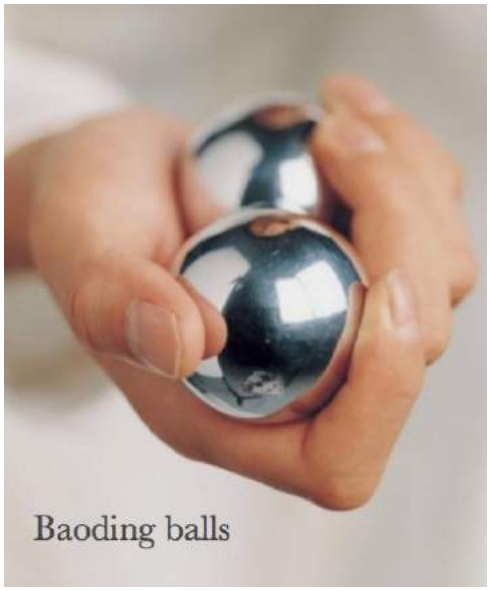

Fig. 7. Baoding balls, Chinese health balls.

Based on the Chinese health ball, the new concept of utilizing health balls to achieve the higher level of physical health is developed to help older adults practice their hand functions. The prototype is shaped like a ball, and finding the most comfortable material that can be easily used by seniors is essential. Considering their physical condition, the test and tool should be gentle, easy, and accessible for them. Therefore, the experimental tools utilized a soft malleable gel, clay, or foam (see fig. 8).

Fig. 8. Gel, light clay, and foam stress ball.

A meeting with the dance instructor Ellin Adams at Maple Downs was set to discuss the use of the prototype in the dance class by incorporating it into the existing dance movements with different levels of grabbing and squeezing of the balls (see fig. 9). An initial test with one resident attending the dance class was conducted before the tools were shown and applied in the class (see fig. 10). The feedback on the tool was good and the participants expressed willingness to use the tools during the dance class because she felt her hands become warmer after using the prototypes.

Fig. 9. Discussion with the instructor on the different combined movements performed during her dance class.

Fig. 10. Initial test with one resident in the Maple Downs facility.

After receiving this initial positive feedback, I distributed the prototypes to the entire class. To entice more residents to participate in the test dance class, handmade gifts were given to the people who joined the exercise class. Four additional residents joined the class because of the activities' reward; they were also interested in how the prototypes could improve their hand exercise experience. I conceived of the idea of adding a reward mechanism or creating a friendly competition for the dance class to encourage the residents to use this tool and exercise regularly. In the prototype test class, balls with different materials were used in conjunction with movements such as pinching and grabbing, which were performed following the dance class' music. The residents provided positive feedback for the test exercise and expressed their desire to continue using the prototypes in future classes(see fig. 11).

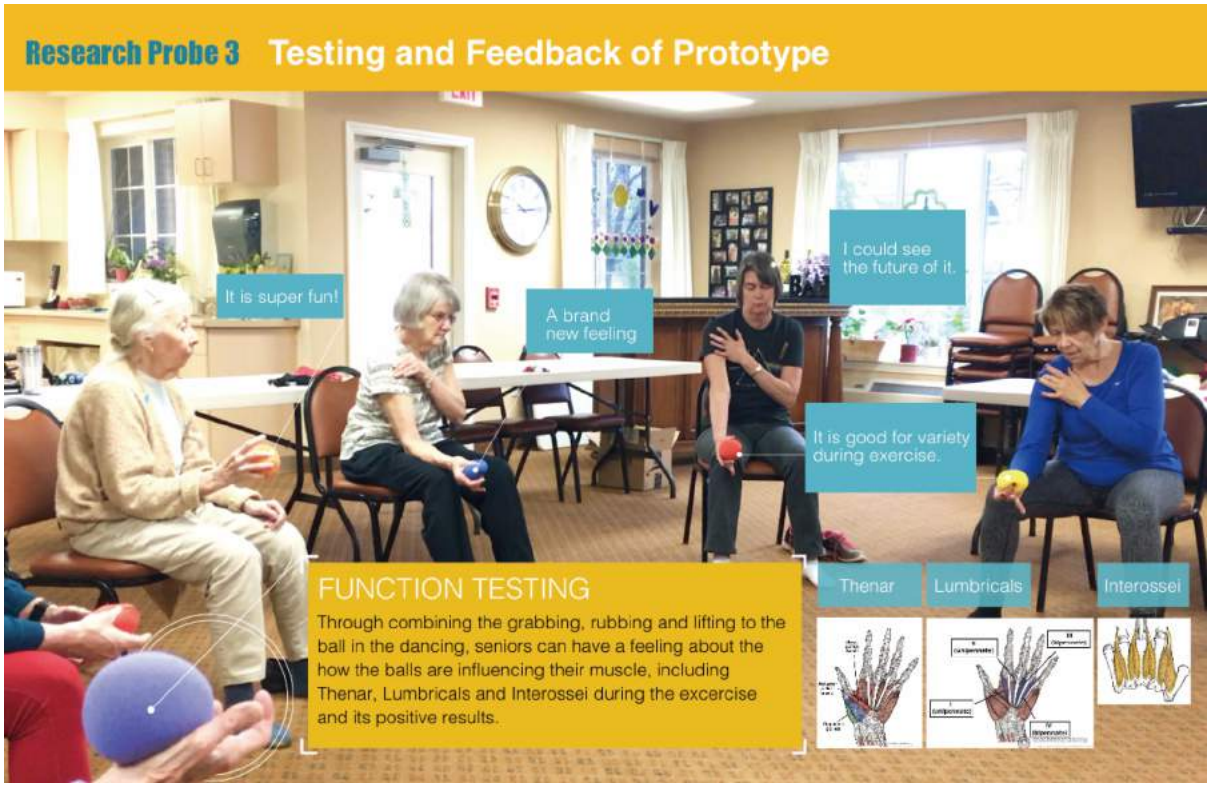

Fig. 11. Function testing of prototypes.

Marion and et al. gave the following feedback. (1) One of the interviewee said, “This is a brand new feeling for me. I could feel oxygen flowing into my hands when I squeezed the ball. We work our fingers and we have to stretch them. I use a lot more finger stress for the ball and for the various materials, such as clay. I could use my fingers to make any shape I want. It makes me use my imagination more.” (2) Another interviewee noticed “It is good for variety during exercise. My mother’s ankles are distorted; she finds a way to move her fingers. It is a way to get relief for her. I think this tool could be an interesting part during our exercise. I can see the potential it has to help our body.” (3) According to one of the other interviewees, “I could see its potential. It is really helpful for my arms and shoulders. I could develop some of my own exercise methods. It may help me to zip my coat easier.” After the test, foam was voted as the most popular material; it made the participants feel comfortable, and it showed sufficient intensity to exercise their fingers.

After a field trip in Maple Downs' living environment, another opportunity was identified. Independent living facilities such as Maple Downs use big screen televisions to share information and post notices in common areas (see fig. 12). This medium could be a good platform to share residents' exercise accomplishments; the information can spread easily.

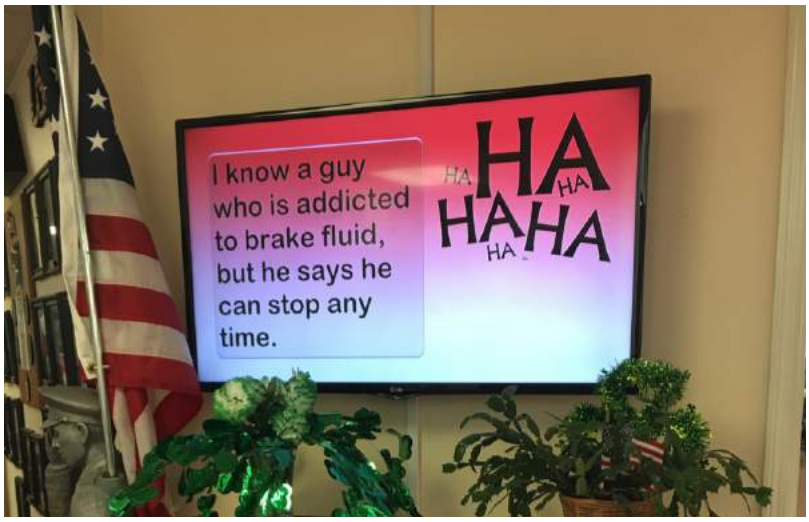

Fig. 12. Information sharing screen located in the common area in Maple Downs.

Outcomes

The final outcome is an exercise service called PB Exercise System. PB refers to "positive ball," a colored foam ball that plays a prominent role in the system. The PB Exercise System comprises the foam balls, related applications, an instruction book, and an instruction video.

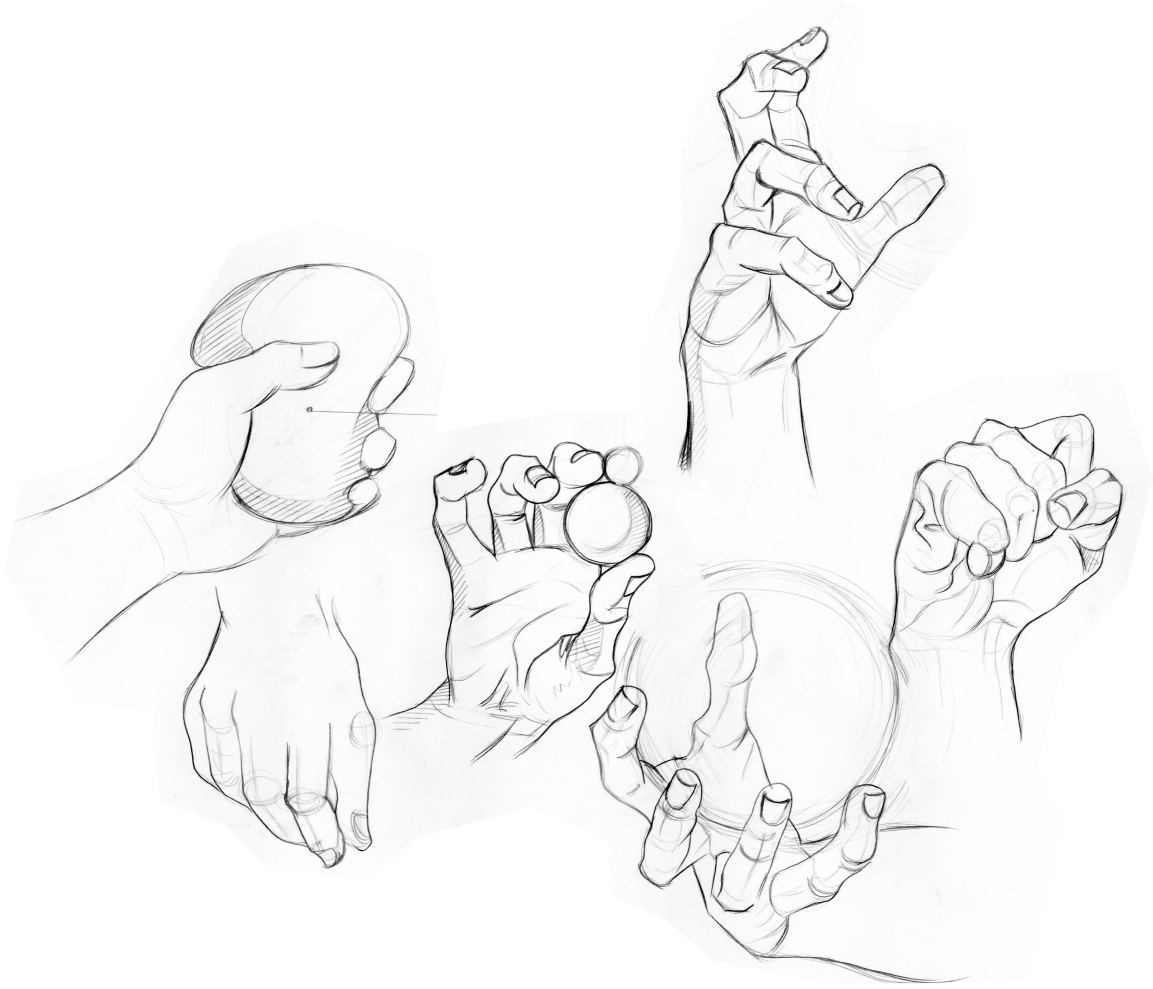

Fig. 13. Sketch of the positive balls of different sizes with various hand movements.

Positive Balls

The positive ball prototype is shaped like a hollow-core ball made of soft foam. The two different sizes are 3.5 and 2.3 inches. Both sizes can be used in dance classes. The smaller one is pocket-friendly and thus allows older adults to exercise their fingers anywhere (see fig. 13). A sensor is placed inside the ball to monitor the acceleration and pressure of the ball; the sensors collect data generated from the user's hand movements and transfer the information to an application on a smartphone, iPad, and a main system located via

Bluetooth. The sensor is attached in the detachable part of the foam ball; taking this foam lid out and changing the sensor or battery are easy (see fig. 14).

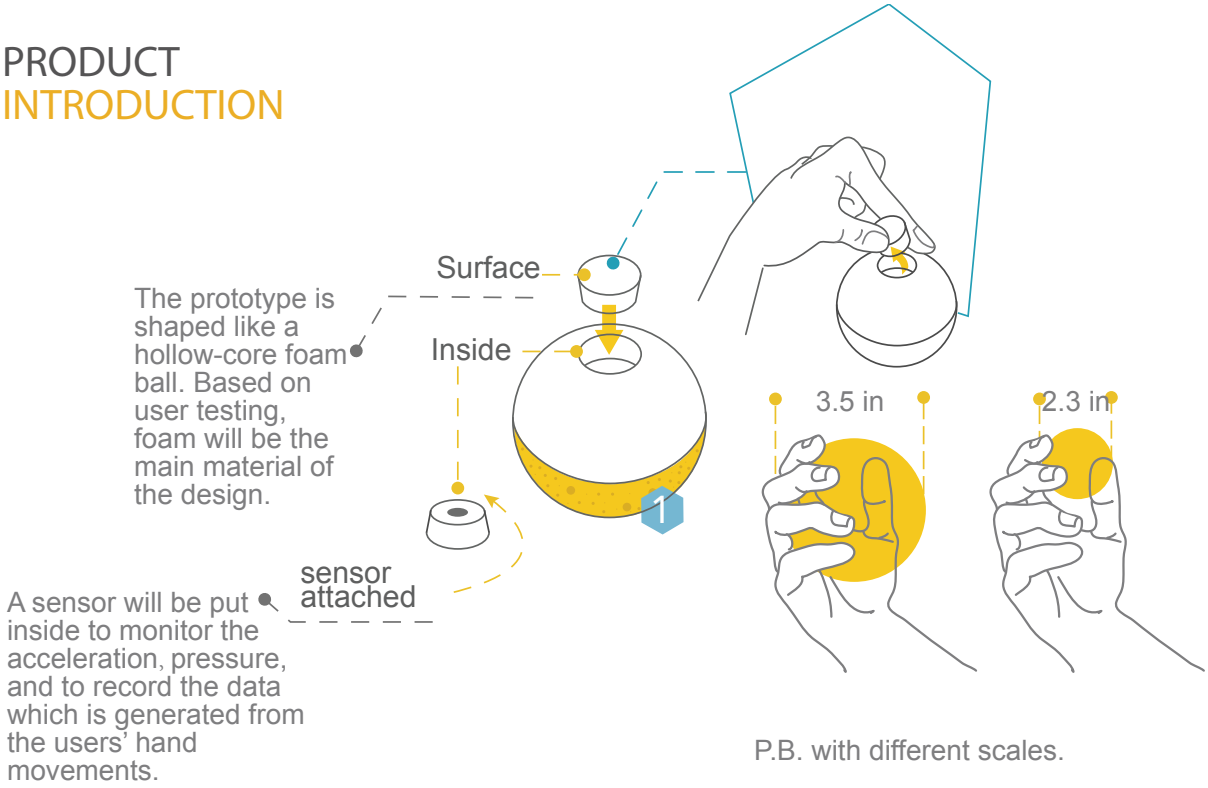

Fig. 14. Positive ball exercise design introduction.

PB application and information sharing system

The PB application allows older adults to check and control their exercise processes efficiently. They could use this application on a smartphone or an iPad with a big screen (see figs. 15 and 16). People's exercise data can also be sent to a big screen television located in an independent living facility's common room (see fig. 16). For the application on an iPad or smartphone, the design principle mainly considers the user experience of older adults and others who need to increase hand strength. A simple interface was designed with a few large icons and easy control. With larger icons and accessible control methods, it will be much easier for seniors with visual impairment to play with the application.To encourage people to

use the PB Exercise System, a small game involving users performing finger dexterity exercises is being developed (see fig. 15). Users water the "flower" in the PB application via their finger exercise achievements. When they complete their goal, the seedling blooms. A friendly competition also happens in the dance group. The top three results are shared on the big screen located in the common area to encourage people to participate in the hand dexterity exercise and join the group (see fig. 16). For the people who prefer not to use technology, the instructor's application could connect with those seniors' PB and share the exercise data with them after the dance class.

Fig. 15. PB Exercise System application concept.

Fig. 16. PB application stationary.

PB Instruction Book

The PB Instruction Book includes five sections: Problem Statement, Know Your Hand, Design Process, Product Introduction, and Operating Guide. The weakness that seniors might face in the future because of a decline in hand skills is shown in the Problem Statement section. For example, the book points out that losing hand strength makes it difficult for people to use their trigger finger and hold things. These warnings can help people self-assess their current hand function condition. Moreover, the book also reminds users to check with their doctor before performing these exercises to ensure the safety of each individual.

The Know Your Hand section discusses people's hand muscle names and distribution with detailed clinical information. The image of a hand is printed on clear film so that users can place their hands under the clear film page to overlay their hand muscles (see fig. 17). This section can help them to understand their hand better. Thus, older adults can identify which of their hand function is declining.

Fig. 17. Example of the Know Your Hand section in PB Exercise System instruction book.

To help users understand the exercise system's purpose, the Design Process section provides a simple, quick review of the system from a research standpoint. After this section, the book shows the basic concept with images that describe the PB's design principles (see fig. 14). The final section of the instruction book is the Operating Guide. This section illustrates the movements using PB, teaches the step by step motions, and highlights the related muscles for corresponding movements (see fig. 18). Users could also download a digital copy of the book to their computer, iPad and smartphone.

The thumb intrinsic musculature constitutes approximately 40% of the total intrinsic musculature of the hand. Three of the main muscles (*Oblique adductor pollicis*, *Opponens pollicis*, and *Flexor pollicis brevis*) play important roles in stabilizing the thumb during

strong pinch grips of objects, and these commonly show age-related dysfunction. (Carmeli, Patish, and Coleman 147)

Fig. 18. Operating Guide section of instruction book.

The instruction video comes with the same information as the instruction book, however the video also incorporates lively background music. In this way, people can learn how to use the PB more vividly (see fig. 19). The instruction book is compact and easy for people to bring anywhere to improve their finger dexterity.

Fig. 19. PB instruction video.

Feedback

The design idea and low-tech prototype were then used as part of a class at Maple Downs. Instead of holding nothing during exercise, older adults hold a simple light weight tool to perform hand movements, such as grabbing and rubbing, and achieve exercise efficiency. Good feedback was received from the residents, the instructor, and staff who worked on managing the seniors' daily activity schedules. They believe the PB Exercise System can remind and motivate the seniors in the facility to exercise and can encourage more people to participate in the dance class and start to improve the dexterity of their hands. The PB prototypes provided a brand new feeling for their class and residents can easily see the advantages of using it. Participants are giving positive feedback. As one of the residents in Maple Downs said: "PB ball gave me something to play with, and I can squeeze it to make my finger strong."

Summary and conclusions

According to the research and my observations, older adults commonly face a decline in their hand function and manual dexterity; negatively influence their daily lives. Compared with designing a high-tech tool that captures movements of the entire body as older adults exercise, implementing low-tech design sources can help seniors improve their hand function immediately, and at lower costs. The PB Exercise System can help seniors maintain and improve their finger dexterity and make daily hand use easier to maintain. A future design could also include a light that's positioned within the ball; this light can serve as an alert indicating the sufficiency of the grabbing force.

Fig. 20. PB Exercise System Final Exhibition.

Thesis collaborating participants.

FEB 03 2016

Ellin Adam

Yoga and Nia Instructor at Nia in Fayetteville and Manlius, NY.

Through the interview with Ellin Adam, more information was learned about Maple Downs' older adults' exercise routine before conducting further interview and questionnaire research with participants in facility.

Residents in Maple Down Facility

The participants in Maple Downs' Nia dance class.

According to the observation of participants' dance classes and analysis of their exercise movements to find those residents' hand dexterity issues, which I needed to be focused on in my design.

FEB 08 2016

MAR 10 2016

Ellin Adam & Residents in Maple Down Facility

1. A meeting with the dance instructor Ellin Adams at Maple Downs was set to discuss the use of the prototype in the dance class by incorporating it into the existing dance movements with different levels of grabbing and squeezing of the balls.
2. To test the function of PB balls and receive the feedback from participants.

Anne Whitaker

Occupational therapist in Menorah Park facility.

Helped with the knowledge with older adults' physical and mental exercise care.

APR 10 2016

MAY 01 2016

Karen Goblin

Enrichment coordinator of Maple Downs.

Helping with managing dance class to keep using PB Exercise system during residents' exercise and introducing PB Exercise System to more residents in Maple Downs.

Fig. 21. Thesis collaborating participants.

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ABOUT ME

As a collaborative designer, I possess a wide range of skills and a problem solving mindet. I also enjoy working with people from various backgrounds and strive to get the most out of every project. According to the project needs, I'm able to shift roles in and support the team from multiple perspectives, such as graphic designer and user experience designer.

EXPERIENCES

2016 User experience design for older adults' well-being, "Grey is the New Black: Design for Better Aging" project, Maple Downs facility, Syracuse, NY.

2015 Social network design, TRAID Center & Project Adapt Library at Access CNY, Syracuse, NY.

2014 Industry design and service improvement, design projsct, Food Bank of New York, Syracuse, NY.

2014 Indepentant design research, international student experience at Syracuse University, NY.

2014 Project accessibility assessment, Phi Delta Theta fraternity and ADA (Americans with Disabilities Act) Program at Syracuse, NY.

2013 Advertising strategy and design, Sleemon Mattress Group Co. Qinhuangdao, China.

2013 Visual identity design, Makider online store, Dalian, China.

EDUCATION

Syracuse University College of Visual and Performing Arts, Collaborative Design, Master of Fine Arts (MFA), Syracuse, NY.

Luxun Academy of Fine Arts, Art Design, Bachelor of Arts (BA), Dalian, China.

SKILLS

- Branding
- Graphic Design
- UI Design
- User Experience Research
- Information Design
- Design Thinking
- Illustration and a solid fine art background

TOOLS

- Ai Illustrator ●●●●●
- Ps Photoshop ●●●●●
- Id InDesign ●●●●○
- Ae After Effects ●●●●○
- Sketch Book SketchBook ●●●●●
- Sketch Up SketchUp ●●●●○