rhythm

fitness for seniors

Melissa Stocco

Industrial Design Thesis Report

Music-Inspired Fitness Solution for Seniors

by

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Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Industrial Design

Faculty of Applied Sciences &Technology
Humber Institute of Technology and Advanced Learning

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April 18, 2023

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abstract

Sedentary or inactive lifestyles have been increasing among senior adults and have contributed to increased rates of falls, heart disease, obesity, diabetes, premature mortality, negative psychological effects, as well as other health risks. Inactive lifestyles can reduce seniors' functional mobility, decrease their quality of life (QoL), and increase their chances of losing their independence earlier in their life. Rhythm is a smart and gamified fitness equipment set for seniors that uses music, lights, and haptic feedback to inspire movement and exercise. Rhythm devices emit music and light as they work through the fitness challenges. The solution provides a convenient way for seniors to strength train to maintain muscle mass and functional mobility as they age. This solution will aid seniors to enhance their quality of life and make exercising a more enjoyable experience. Rhythm implements elements of activities that seniors already enjoy, such as social time, music, and creative outlets to improve their exercising experience. In addition, Rhythm provides safety features to reduce barriers to exercising, such as fear of falling. The set includes four products: a workout bench, fitness mat that uses robotic fabric, a fitness ring, and dumbbells.

acknowledgments

The completion of this thesis project was only possible due to the support and guidance of my supervisors, family, friends, and classmates. I would like to thank my supervisor Catherine Chong for her feedback and endless work to ensure that this project reached its full potential. Thank you to my Subject Matter Advisor, Micheal Vander Velde, and Fredrick Matovu for their feedback and guidance.

Next I would like to thank my classmates who were always there when I needed them most. I had a strong support system and someone was always available to ask a last minute question or share some super glue. Specifically, thank you to Mary-Beth Scully, Hannah Dumancas, Charlotte Watkins and Thomas Purchase.

Finally, thank you to my partner Joseph Stapleton who has always believed in me and has helped me pursue my dreams.

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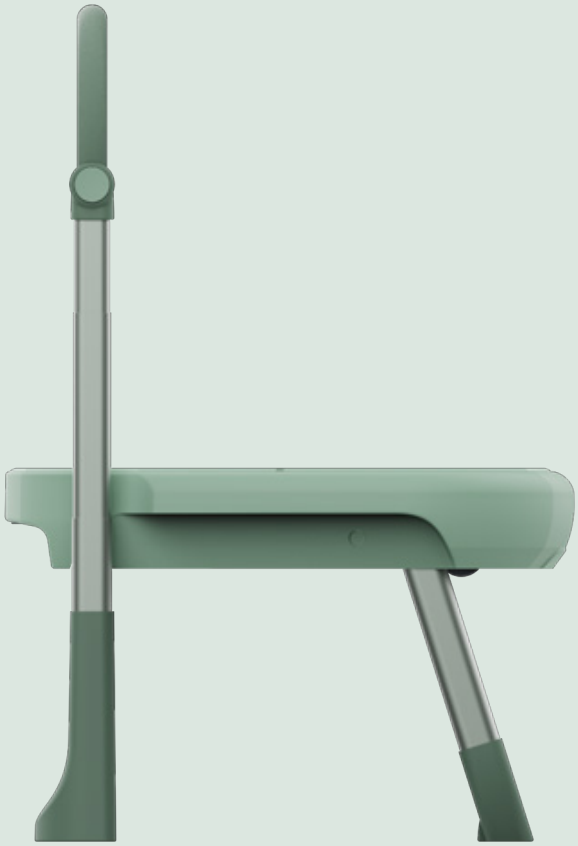


1.1 Problem Definition

Canada's largest generational group, Baby Boomers, will all be over the age of 65 by 2030 and are projected to represent 23% of the Canadian population by 2031 (Arriagada, 2018). Sedentary or inactive lifestyles have been increasing among senior adults and have contributed to increased rates of falls, heart disease, obesity, diabetes, premature mortality, negative psychological effects, as well as other health risks (Statistics Canada, 2021; McGowan, 2020). Inactive lifestyles can reduce seniors' functional mobility, decrease their quality of life (QoL), and increase their chances of losing their independence earlier in their life.

This design project will research how older adults stay physically active, barriers they face to being active, and ways tools can improve their activity levels and physical mobility. This study will consist of surveys, interviews, and observations of the different stakeholders involved including seniors, medical professionals, and caregivers. The research from this study will provide insights to design a product or solution that will help older adults be physically active, motivate adults to participate in physical activity, and improve their overall mobility.

1.2 Rationale & Significance

There are four key aspects that must be determined in order to propose a design solution to the problem definition. The first is understanding how senior citizens currently spend their time and daily tasks they perform. This will aid in determining the activities that seniors enjoy participating in to help establish how exercise can be integrated into their daily lives. The second is to understand the sociological and physiological barriers that hinder senior citizens from exercising. To determine what stops seniors from engaging in physical activity and how social aspects of their lives affect their activity levels. Third, to understand what types of physical activity seniors currently engage in and what types of exercises they should be performing to prevent falls and maintain their independence. Fourth, to understand how current fitness equipment serves seniors and what types of equipment exists for seniors. This will establish where the gaps are in the market and how the design solution should function to provide the most value to senior citizens.

1.2.1 Key Questions

The key questions that will be answered through this investigative report and will be addressed through the proposed design solution are:

- What types of activities do seniors take part in their daily lives?
- What motivates seniors to participate in activities or tasks?
- What engages seniors to partake in physical activities?
- Why do seniors not participate in physical activities?
- What barriers do seniors face when trying to stay physically active?
- What types of exercises improve functional mobility for seniors?
- How are current products on the market serving the target demographic?
- What types of fitness activities do seniors currently participate in?

1.2.2 Investigative Approach

The investigative approach to this design project is to conduct both primary research and secondary research on the proposed topic and target user. In addition, various forms of analysis will be used to break down and understand the research insights. This research and analysis will help to frame the problem definition and provide key insights that will help formulate potential solutions. The following research methods will be used:

Primary Research

- Surveys
- Interviews
- User observation
- Video observation

Secondary Research

- Benchmarking
- Literature review

Analysis

- Journey & task map
- Empathy map
- Benchmarking
- Ergonomic study

1.3 Background/History/Social Context

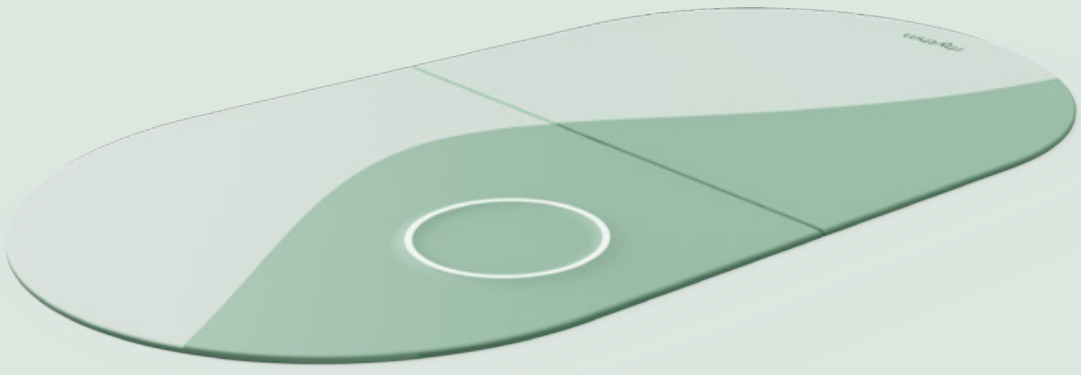
Healthy Aging in Canada (2005) found that there were 5 key areas that should be focused on for seniors aging. Three of the areas that will be focused on in this report are fall prevention, physical activity, and social connectedness.

The Public Health Agency of Canada (2014) reports that falls lead to seniors becoming dependent and transitioning to long-term care (LTC). One third of seniors are discharged into LTC after being hospitalized for a fall with half not previously living in LTC. Falls cause physiological effects, such as a fear of falling, which can increase seniors' risk of falls. In addition to this, obesity in adults aged 55-64 has grown from 20% in 1979 to 30% in 2004. For adults aged 65-74, in this same time period, this rate increased by 5% and 13% for those 75+ (Statistics Canada, 2004). The injuries from falls, rates of obesity, and stays in LTC have a significant impact on the healthcare system and financial cost. Seniors' fall injuries alone cost the Canadian government $2 billion yearly.

Physical activity has been found to be preventative of immobility, falls, and obesity. Exercise was found to be 5 times more effective than other types of interventions for falls, “physical activity should be regarded as an actual “medicine” due to its large array of health benefits” (Public Health Agency of Canada, 2014; Billot, 2020). Statistics Canada (2018) reported that in 2015 seniors are less active than they were in 1986, spending less time on active pursuits. The recommended weekly Moderate-to-Vigorous Physical Activity (MVPA) is 150 minutes per week. In 2018-2019 Statistics Canada found only 33% of seniors aged 60-79 met this requirement, down almost 20% from those aged 40-59 (Statistics Canada, 2021).

Seniors experience physical and psychological barriers to being physically active such as physical pain (joints), fear of falling, lack of time, fear of going alone, not being fit, not having a car, inconvenience, weather, no energy, not seeing benefits of exercising, being unfit, and not being part of a group (Crombie 2004; Hornyak, 2013; Harrison et al. 2020). Crombie et al. (2004), a study done in the UK, found that lack of interest was the strongest deterrent for seniors to exercise (65-84 years old). HealthlinkBC (2012) from the government of British Columbia also recognized a number of barriers to seniors' staying activity including difficulty with transportation, uninterested in current active programs, no time (i.e. caring for others), lack of physical balance, and stiffness. Healthy Aging in Canada (2005) reported how social connectedness can increase seniors' health by 62% based on data from a survey by Canadian Community Health Survey. Harison et al (2020) also found a theme through their research that identified social interaction as a motivator for seniors to participate in exercising. This included exercising to stay healthy for loved ones or knowledge they would live a longer life if they continued to be physically active.

research 02



2.1 User Research

Survey

Key insights that can be taken from the results of the preliminary survey (Appendix B) are that many seniors include walking as part of their daily exercise routine (39% mentioned walking as part of their exercise routine). Walking could be incorporated as part of the design since it is an activity that seniors enjoy. Seniors mentioned motivation, weather, flexibility, pain, and finding time as part of what makes exercising difficult for them. A design that addresses these pain points would be beneficial for seniors. Seniors also had basic functional mobility issues such as going up and down stairs or getting up from chairs. A fitness device could be designed to improve their functional mobility to increase the quality of their day-to-day life.

The healthcare workers survey echoed similar sentiments about walking for seniors and weather impacting their ability to exercise. Healthcare workers also discussed the impact of injuries on seniors from falls which occur due to their lack of mobility. The design direction of prevention of these injuries through physical exercise is an area that will be focused on.

Caregivers discussed the difficulties of aiding their senior family members. At this point, the seniors they cared for were very dependent on them to perform daily tasks and could not exercise due to their physical limitation and pain. Their lack of balance, flexibility, and muscle strength made it difficult to perform exercises. This group of seniors is likely out of scope for the project, but are an example of the type of injuries and lifestyle the design solution will be attempting to help prevent.

User Interviews

There were six interviews conducted as part of this research report. Four of the interviews were conducted with seniors, one with a physiotherapist, and one with a senior personal trainer.

The interviews were very insightful into the daily routines of seniors and the types of activities that they participate in their daily life and how their mobility affects them. Senior #1 discussed in detail how music was inspiring to her and that dance allowed her to be creative with movement and gardening was like therapy for her. She felt the garden was like a canvas where she could express herself like art. This was a very interesting insight. A fitness solution or design could provide an outlet for the user to not just physically exert themselves, but to also be creative while they perform the activity.

Senior #2 talked a lot about getting back into exercising and fitness. She had suffered some injuries from falls and wanted to maintain her mobility. She was not motivated to exercise in itself to stay healthy. She discussed that she was part of an exercise group with a personal trainer "Everybody has the same problems because they are the same age." It was important for her to be

able to socialize with friends and being part of the group gave her another opportunity to make connections and socially interact. She said that she needed to be part of the group to do proper exercise because just watching someone on TV did not motivate her to do the exercise. An important design consideration for sedentary seniors is to provide them with motivations and goals that are unrelated to exercise and, if possible, make the activity seem like it is not exercise. She liked enjoying her life and traveling, but was not interested in the vigor of exercising for the sake of it. A design insight from the interviews with senior interviews #3 and #4 was to be able to work exercise or fitness into their daily routines.

The physiotherapist highlighted important points about the types of exercises that seniors are able to do and how many exercises seniors can do at one time. The physiotherapist gauged what was possible for their clients and provided them with low impact exercises and often focused on exercises that improved their functional mobility. It will be important for the final design to focus on exercises that improve functional mobility

The senior personal trainer provided many insights into types of exercises that are good for older adults. She primarily focused on strength training since this was very important for older adults to maintain their muscle mass. Implementing strength and resistance training into the design solution will be an important design consideration, in addition to balance and flexibility. The personal trainer explained that she targeted specific areas and provided strength training for muscles that are needed to be functional (i.e such as squats for quads). In addition, it is important to have modifications and steps for the different levels that each person is starting at, so they can get to the level that they need to be. For the design solution it will be important to implement modified levels for seniors at different starting points in their fitness journey.

Video Observation

The two videos (Appendix B) that followed the day in the life of seniors were both very active but they took a “siesta” or nap in the middle of the day. The first woman was more physically active, she went on a lot of walks and talked about practicing karate. She said that exercise was a really important part of her day. She also spent some of her days working part-time to stay active and busy. She did spend more leisure time during the end of her day, which she also spent with her family and husband. Overall she was less socially active than the 89 year old from the second coded video. The 89 year old did not deliberately exercise but she was very social and had an activity throughout most of her day. Most of her activities were social and allowed her to spend time with friends, family, or her community. Both women were still very mobile and were able to drive their own cars as transportation. Key points from the first two videos that can be applied to design were that it is important for seniors to be able to take breaks and not be too vigorous with their activities. Seniors

enjoy walking and that activity could be incorporated with other types of exercise. Another important discovery from the observation from the first two videos is that being social motivates seniors to get out of the house and be active. Seniors feel accomplished when they are able to do small things like getting ready in the morning or making their bed.

The third video (Appendix B) depicted what life is like in a nursing home. In this video the residents of the home needed care and often could not walk without mobility assists. They discussed the value of human communication and connection which was very important for the seniors.In comparison to the other videos there were a lot more negative feelings about the treatment of elderly by society and neglect from their families. They discussed how social interaction can help seniors thrive, which was very apparent in the second video of the 89 year old. Overall social interaction was a very important aspect of leading an active life for all of the seniors in the video. This highlights social interaction as a very important point to consider when designing for seniors. The nursing home showed the detriment social isolation can cause to seniors, but also how a nursing home can provide that interaction to lift up seniors in need.

2.1.1 User Profile - Persona

Table 1: Primary, Secondary, Tertiary Users

Primary User	**Secondary User**	**Tertiary User**
65-85yr old Sedentary Senior	20-40yr old Family Member	20-40yr old Community Center Worker
• Does not exercise • Does not participate in physically active pursuits • Lack of exercise contributes to weakened muscles and risk of falling • Does not walk outside in the wintertime • Only pursues activities that bring them joy • Starting to develop difficulty with functional movements	• Helps senior with their technical difficulties at home • Participates in physical activity with seniors • Enjoys having social activities they can do together with their senior family member	• Sets up system at the community center • Helps seniors with technical difficulties • Sometimes participates in the physical activity with seniors

This thesis project is specifically looking at the age demographic of seniors aged 65-85 years. This demographic skews more towards the female gender, making up more than half (53%) of those 65 years or older. Women take up a larger percentage of the population as age increases (Statista,

2022). The majority of the population 65-74 years completed no schooling, completed highschool or received a postsecondary certificate as their highest level of education (Statistics Canada, 2016). Canadians of all ages with lower education are less likely to engage in physical activity (Dogra, 2010). Those over the age of 55 have larger purchasing power than any other age group in Canada as of 2016. The net wealth of those 55-64 being a median of $670k and those 65 and over being $517k (Norris, 2019).

User Behavior

Before seniors retire they are engaged in less active pursuits for both genders. After retirement seniors have more time to spend on other activities. Statistics Canada defines active pursuits as, "exercising, socializing and using technology" (Arriagada, 2018). Seniors of both genders increase their passive leisure time, with men spending more time on passive leisure before and after retirement. Seniors spend 2.3-2.7 hours on active pursuits every day. On a more granular level, seniors that participated in general "physical" activities spent roughly 132-133 minutes on average. The participation rate for men (%44) was significantly higher than women (%39) (Arriagada, 2018). Statistics Canada defined the participation rate as "the proportion of persons who reported having done an activity on an average day" (Arriagada, 2018).

When starting an exercise program "50% of individuals drop out within the first six months" (Etnier et al., 2016). Seniors typically have low participation rates for "workout" activities and tend to participate in other activities where they can be physically active (such as gardening). 60% of seniors in the United States track their health information on the internet (Etnier et al., 2016). Etnier et al. (2016) found in their study that participants were motivated to complete their studies exercise program since they were invested in the results of the research (providing them a sense of purpose), it was group exercise (social), the program was accessible, and they felt encouraged by the potential health benefits.

After spending on their residence seniors food, clothing and care are the largest expenditures for older adults. Seniors, in their early 70s, do spend a sizable amount of their retirement funds on recreational activities, spending almost 6% (Lafrance, 2011)

Primary User Persona

Name: Gladys Smith
Age: 65
Job: Retired
Net Wealth: 600k
Education: High school graduate
Relationships: Widow
Location: Toronto, ON
Main Physical Activity: Zumba
Frequency: Once a week
Group/Solitary: Group
Other Activities: Gardens, watches TV, reads, plays cards once a week

Profile

Gladys is 65, European descent, high school educated women. She is a retired teacher and mother to 3 children and is now a grandmother. Gladys enjoys spending time watching TV and relaxing with a book in her home. Gladys tries to get out a few times a week for social interactions, such as playing cards and going to Zumba.

User Behaviour

When Gladys was a teacher she had to stand all day and walk around her classroom. She did not prioritize exercising outside of work as she was regularly active during her working hours. She has now retired and does not spend time on exercising, but prefers to do entertaining or pleasurable activities such as watching TV, playing cards with her friends, or gardening. Recently, Gladys has fallen a few times and injured herself due to her declining strength and balance from her sedentary lifestyle.

Relationship with Physical Activity

Gladys has never been to a gym and did not play many sports when she was a child or young woman. Gladys did not know how to maintain her physical health, but felt that going to Zumba once a week was enough. Gladys is now worried about her health declining due to her recent injuries and the possibility that next time she falls she may become immobile. Gladys does not know if she can improve her physical condition or how she would start doing that.

Figure 1: Persona

2.1.2 Current User Practice

Currently, sedentary seniors do not participate in physical activities or participate in very low levels of physical activity. Seniors spend a lot of their leisure time watching television, on the computer, tablet or phone. Sedentary seniors may have some active pursuits they participate in such as gardening or going on walks. These seniors do not know how to get the exercise they need but know that it is important for their physical health. Going to a gym is too daunting and not a task that sedentary seniors would be interested in.

2.1.3 User Observation - Activity Mapping

The following task map was developed based on the participant observation conducted through the primary research. The task map goes through the steps of taking a workout class for seniors.

Table 2: User Task Map

TASK: Working Out Class	Ergonomics	Efficiency	Interaction	Satisfaction
Prepare for workout: get water bottle, change, go to class	Pick up objects Bending Walking	Takes time to get ready for working out Need a ride	N/A	Irritating to need to take the time to prepare
Strength Training	Holding weights in hands	Need to figure out which weight to use for each exercise	Grip on the weight	Grip comfort may make performing the workout more enjoyable
Balance Training	Need stable ground to be able to stand	Easy to do with no equipment. Difficult without guidance	N/A	Can be difficult to perform with fear of falling
Cardio	Need space to complete the workout	In general, seniors need more space to do this type of exercise. Can be difficult to seniors due to fear of falling	N/A	Takes more physical exertion to perform
Cool Down	Need to be able to get on and off the floor	Hard for seniors to make it on and off the floor		Relaxing moments
Return Home	Pick up objects, bending, walking	Takes time to return home, need a ride	N/A	Takes time to return home.

Main Usability Issues

Gains:

- Social engagement and community is important for seniors and can be used as a tool to encourage or motivate seniors to participate in exercise.
- Guidance is important for seniors to be able to know how to perform exercises and what exercises do
- Seniors need exercises tailored to their personal difficulty level

Pains

- Seniors are not always able to train with others
- Seniors are not alway motivated to perform workouts or push themselves
- Seniors fear falling and are not always confident in their balance and flexibility

Usability & Ergonomics

- To perform strength training seniors need to grip and hold onto weights
- Seniors may need something to hold onto to support them while they exercise

Efficiency

- It is not always practical for seniors to go to workout classes, due to lack of funds or transportation

Interaction

- Seniors need comfortable grips, especially for those with arthritis

Satisfaction

- Exercising can be difficult and without other external factors for motivation, for example social or entertainment, exercise can be not very enjoyable.

2.1.4 User Observation –Human Factors of Existing Products

Existing products would primarily target younger adults for their human factors ergonomics. Seniors overall body size tends to be smaller as humans shrink as we age, which could affect seniors ability to use current fitness products, especially for senior women. Current products that can be referenced for ergonomics are dumbbells, pilates rings, workout mats, and workout benches.

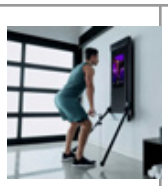
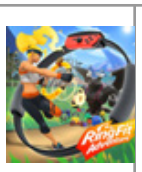
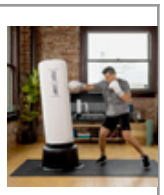
2.1.5 User Observation - Safety and Health of Existing Products

Although there is not much literature on the subject, fitness equipment traditionally does not use many sustainable materials. These products are designed using different types of plastics for their durability, longevity and sanitization. Durable materials are required since most of these products are living in gyms where they need to be able to withstand being wiped with chemicals, regular use, and various types of workouts. Gyms use up a large amount of space which requires a lot of wasted energy to house and store this equipment (Eichenberger-Archer, 2022).

2.2 Product Research

2.2.1 Benchmarking - Benefits and Features

Table 3: Benchmarking Fitness Equipment

								
	1	2	3	4	5	6	7	8
Product	Amazon Basics Neoprene Workout Dumbbell	NordicTrack iSelect Adjustable Dumbbells	Lululemon Studio - Mirror Family	Tonal	Wii Fit	Ring Fit Adventure	Tempo Studio Plus	FightCamp
Price	$51.61	$679	$2095	$3245	$195	$99	$2245	$499
Benefits								
	- Low cost - Durable - Safe - Quick identification - ideal for fitness classes	- Adjust weights automatically - Adjust quickly - Stay organized -Save space - Rapidly switch between exercises	- fits any wall in your room - Easy set up - Beautifully designed - Join the community - Meet new friends -personal exercise modifications - Live interaction	- Tough workouts - Form guidance - Ongoing motivations - Boost your confidence - Adaptive weights Tailor every rep	- Aerobic activities - fitness with fun - design for everyone - spend as much (or as little) time as you want	- Keep you moving - Workout the way you want - Fun - Jump straight into action - easier to work harder	- You progress faster - Get guidance not guesswork - Premium quality - Learns your body - Superior form and function	- Uniquely satisfying workout - Fight boredom with variety - Move to the groove - Go-getters become goal-getters - friendly competition

			with instructions					

Features								
Smart	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Weight of provided dumbbells/weights	2, 3, 5 pounds	Up to 123 pounds	10, 15, 20 pounds	Up to 200 pounds	None	None	50 pounds	None
Material	Iron with Neoprene coating	Steel	Carbon steel frame	Steel	Plastic	Plastic	Aluminum frame	Not disclosed looks like a polymer textile for the bag
Screen Provided	No	No	Yes	Yes	No	Yes	Yes	Yes
Workout Guidance	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Other Features	- Non-slip grip - 6 dumbbells - Printed weight number - hexagon shape so they do not roll	- alexa voice controlled - embedded accelerometer Digital weight readout -safety interlock -workout presets - Tray tablet holder - Digital weight readout	- 5 mega pixel front facing camera - 43" HD Display - High fidelity speaker system - Carbon steel frame - real-time data	- Adjustable arms - Touchscreen - Steel construction - Spotter mode - Form guidance - Adaptive weight	- 40+ activities - Set goals - Daily progress - Wii balance board	- 100 levels - Quick play mode - Adventure mode - Minigames - Custom workouts - Ring-con (joystick)	- Free weights - Folding Bench - Dedicated coach - 3D sensors automatically recognize weights - Colour coated weights - 42" touch screen	- Real-time metrics - Punch trackers - Trainers - Music stations - Unique combinations (of exercises) - Leaderboard

Takeaways

Top Benefits of Benchmarked Products

1. Guidance for workouts
2. Quick
3. Motivating to workout
4. Customized workouts
5. Community aspect (competition, meet new friends)

Top Features of Benchmarked Products

1. Touch screen
2. Multiple activities/workouts
3. Voice control
4. Progress tracking
5. Weights or automatic weight systems

2.2.2 Benchmarking –Functionality of Existing Products

Functionality of the product are the features that allow the product to perform its intended purpose. The benchmarking determined the different features that are common among the smart fitness equipment researched. The features analyzed are the weight of the equipment and the overall size of the product.

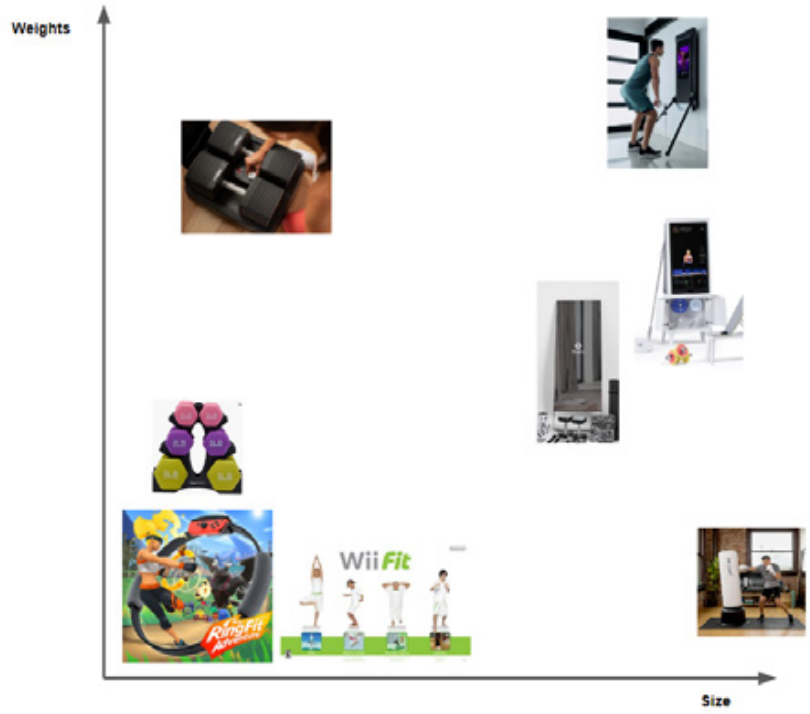


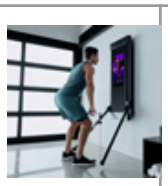
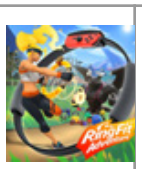
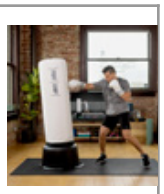
Figure 2: Functionality Graph

Takeaways

- Smaller equipment tends to have less weight, although not always
- The larger equipment takes up more floor space in the home
- The home gyms provide more options for working out then the smaller units

2.2.3 Benchmarking –Aesthetics andSemantic Profile of Existing Products

Table 4: Benchmarking Fitness Equipment Form

								
	1	2	3	4	5	6	7	8
	Amazon Basics Neoprene Workout Dumbbell	NordicTrack iSelect Adjustable Dumbbells	Lululemon Studio - Mirror Family	Tonal	Wii Fit	Ring Fit Adventure	Tempo Studio Plus	FightCamp
Over all Form								
Shape	Hexagon	Hexagon	Rectangular	Rectangular	Rectangular	Circular	Rectangular	Cylindrical
Balance	x & y direction balanced	x & y direction balanced	Vertical balanced	Vertical balanced	x & y direction balanced	Balanced	Vertical balanced	Vertical balanced
Style	Casual Athletic	Serious Athletic	Casual Athletic	Serious Athletic	Casual Athletic	Casual Athletic	Tech Athletic	Serious Athletic
Organic/Geometric	Geometric	Geometric	Geometric	Geometric	Geometric	Geometric	Geometric	Geometric

Takeaways

- All the equipment was geometric shaped
- Majority of the equipment had rectangular or hexagonal shapes
- Home gyms were vertical in their directional shape
- Designs were balanced and symmetrical

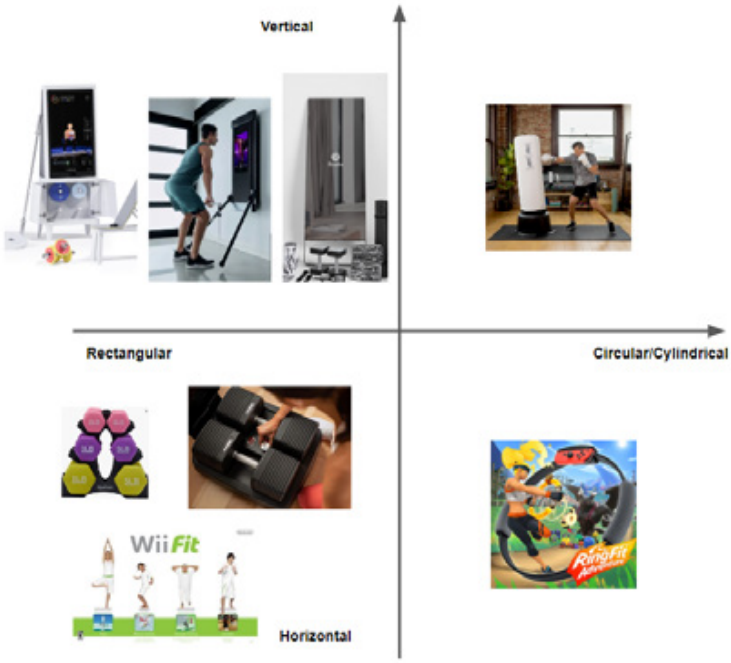


Figure 3: Form Graph

2.2.4 Benchmarking –Materials and Manufacturing of Existing Products

Materials

This section will focus on the materials for the primary components of the fitness system. Current materials used for existing products will be examined as well as sustainable opportunities. Materials for each product in the system including the workout mat, free weights, and workout bench will be outlined.

Free Weights

Free weights are traditionally produced in three different types of metal alloys: cast iron, mild steel, and less frequently stainless steel (KustomKit, 2023). Free weights can also be made of sand, which tend to be larger due to sand being lighter in its mass. Some weights are also made of copper or brass, which is a more expensive metal alloy and is reserved for higher end free weights, such as the Kenko Dumbbell Set, see Table 1 (SSENSE, 2022). Cast iron is the cheapest material but has less impact resistance than steel. Steel can be heavier than cast iron depending on what elements it is alloyed with.

Table 5: Comparison Between Cast Iron, Mild Steel, and Stainless Steel

	Cast Iron	**Mild Steel**	**Stainless Steel**
Weight (1 cubic inch)	0.26lbs	0.28lbs	0.29lbs
Density	0.200 - 0.282 lb/in^3	0.284 lb/in^3	0.00686 - 0.326 lb/in^3
Cost	Cheaper than stainless steel	$0.36/lb	$2.31/Lb
Impact Resistance	Deforms and breaks more easily than steel	Steel has more tensile strength, so it can bend without breaking	Steel has more tensile strength, so it can bend without breaking
Sustainability	All of the metals are 100% recyclable material. Can be recycled to the same quality as before.		

(TW Metals, 2023; Matweb, 2023; Steel Express, 2023; BSSA, 2023; American Iron and Steel Institute, 2020; Metal Miner, 2023; Rapid Direct, 2022; Cohen, 2023.)

Table 6: Free Weight Benchmarking

Brand	**Amazon Basics Dumbbell Set**	**Bala 3lb Dumbbells**	**BalanceFrom 10lb Dumbbells**	**Amazon Basics Dumbbells**	**Kenko - SSENSE Dumbbell Set**
					
Materials	Cast Iron with a neoprene coating	Silicone coating over steel	Rubber coated steel dumbbells	Vinyl coating over steel	Brass with walnut exterior
Cost	$67.64	$59	S47.97	$15.66	$831

(Bala, 2023; Amazon Basics, 2023; BalanceFrom, 2023)

There are a variety of coatings used for dumbbells which can protect the metals from moisture and provide comfort to the user while interacting with the weights. The coatings include: urethane, rubber, nickel, zinc, enamel, vinyl, neoprene, and silicone (KustomKit, 2023; Luna, 2020). The sustainability of each of these coatings has been examined in detail in Table 3.

There are a variety of options for coating dumbbell weights, most of which have some environmental impacts due to their unique properties of high durability and moisture resistance. Zinc coatings on steel or iron is the most sustainable and environmentally friendly option, but will not provide as much protection for the longevity of the product as some of the other coatings (such as rubber, neoprene, or polyurethane). The zinc coating also does not provide comfort to the user when holding the dumbbells. Polyurethane, vinyl, and neoprene are the least sustainable coatings due to their impact on the environment and difficulty recycling or not being recyclable at all. Rubber, TPU, and silicone are not entirely environmentally friendly but provide good material properties for the use case and will provide more longevity for the product (KustomKit, 2023; Luna, 2020). These products also provide the opportunity to create a protective sleeve that can be easily removed instead of a coating which will affect the recyclability of the metal weight.

Table 7: Comparison Between Free Weight Protective Coatings

	Polyurethane	Natural Rubber	Nickel	Zinc	Vinyl	Neoprene	Silicone	TPU
Waterproof Absorption	Yes 0.54 - 1.2 %	Yes	Can chip/scratch off over time exposing iron/steel	Can wipe off over time exposing iron/steel	Resistant to water	Resistant to water	Yes 0.030 - 3.0 %	Yes
Molecular Weight	231000 - 262000 g/mol	-	-	-	-	-	450000 - 850000 g/mol	
Durability	High impact	Can take damage when dropped. Higher abrasion resistance than silicone. Not very weather resistant	Can chip or crack	Will break down over time	Scratch resistant, but does not handle impact well	Resistant to scratches and impact -40 °C to 110 °C	Can be damaged more easily due to abrasion than neoprene. Good weather resistance -50 °C to 230 °C	More durable than silicone
UV Resistance	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Lifespan	50 years	Shorter than urethane	Short	Short	Shorter than Urethane or Rubber	Shorter than Urethane or Rubber	50+ years	Long, but can biodegrade in 3-5 years
Easy to clean	Yes	No	Yes	Yes	Yes	Somewhat	Yes	Yes
Cost	Expensive	Cost Effective	Expensive	Cost effective	-	Higher cost	More expensive than Neoprene	-
Repairability	Difficult	Difficult	Easy	Easy	-	Difficult	Difficult if coated	Difficult
Recyclable	No	Yes	Yes steel can still be recycled	Yes steel can still be recycled	Yes, but it requires special processes	Yes, but not recyclable everywhere	Yes, but requires special processes	Recyclable and biodegradable
Touch	Hard	Soft	Hard	Hard	Soft but slippery	Soft	Soft	Soft
Manufacturing	Non-toxic material, safe once produced. Releases toxins when heated.	Natural rubber contributes to deforestation	Nickel can be dangerous to the environment in powdered form/airborne	Non-toxic manufacturing	Vinyl is considered one of the most dangerous plastics. Chemicals can leach out after production.	Releases toxic chloroprene during production	Silicone is more sustainable than plastics. It is difficult to recycle and is produced with petroleum. Does not leach out toxins once produced	Non-toxic inert material
Other		Can cause latex allergies	Can cause allergies		Typically used for concrete weights			Resistant to oils and grease

(American Galvanizers Association, 2023; Lets Talk Vinyl, 2023; AZO Materials, 2001; Nickel Institute; 2023; Polyurethane, 2023; Solomon, 2021; PBS, 2022; Suzdaltsev, 2016; Xometry, 2022; Zielinski, 2020; Jehbco Silicones, 2018; Marian, 2020; Takeaway Packaging, 2020; ATSDR, n.d.; Dowsil, n.d.; Matweb; 2023; Bend Plating; 2019; Luna, 2022; Techcitytimes, 2020; Omenexus, 2023; Bibs, 2023)

Silicone provides great water resistance and comfort for the user. Silicone is environmentally inert once produced, so it does not pose negative environmental health effects. Silicone can take 500 years to decompose in the natural environment, but is a better alternative to plastics or use of single-use plastics (Jackson, 2020). TPU (a combination of rubber and plastic) has similar properties to silicone but is more environmentally friendly since it can be recycled and biodegrade. TPU has better abrasion and friction resistance which can decrease the longevity of silicone (Bibs, 2023; Omnexus, 2023; Techcitytimes, 2020).

Workout Bench

The main components of a fitness or workout bench are the seat and frame for structural support and height variation. Workout benches tend to be built using steel frames likely due to its strength properties and lower cost in comparison to aluminum. Both aluminum and steel are highly recyclable materials with 100 percent of the metals being able to be recycled without losing quality of the material and can infinitely be reused. Aluminum uses a lot of energy to extract initially, but since the metal is highly recyclable it is still friendly to the environment. It takes roughly 95% less energy to recycle aluminum than extraction (Energy Education; ReMM Group, 2021). The Aluminum Association (2021) reported that, "75% of all aluminum ever produced is still in use today." Like steel, aluminum can be alloyed with other elements to change its mechanical properties. Aluminum has a good strength-to-weight ratio and can be used to produce lighter products, being approximately half the weight of steel (Erectastep, 2020).

The seat of workout benches come in various forms of plastic, such as polypropylene, polyurethane, and often use high density foams or faux leathers. As discussed in the previous section, plastics production processes can be harmful to the environment, but there is a difficulty with sourcing materials that have the mechanical properties required to provide longevity, sanitization, and usability of a fitness product. This does not mean that sustainability cannot be taken into account with the choice of plastic for the base, it's environmental impact and recyclability. For instance, PVC and polystyrene are known to leach toxins into the environment after production. There is the option of using recycled plastics to greatly reduce the environmental footprint of using plastic materials (Green America). Many bioplastics cannot use traditional recycling facilities and often need specialty recycling or composting. Many engineered plastics cannot be recycled or are difficult to recycle due to the combination of plastics, but instead could use recycled plastics as part of their make-up (Wade, 2019; Thryft, 2022).

Table 8: Benchmarking Workout Benches

Brand	FLYBIRD Weight Bench	Reebok Workout Bench	Yes4All Step Platform	Fiar Step Platform	Escape Fitness Workout Bench	ViscoLogic Workout bench	PRISP Workout Bench
							
Material	Alloy steel frame, foam padding, and faux leather seat cover	Plastic	High-density polyethylene	PP with PVC rubber on the bottom to prevent the platform from slipping	Alloy steel frame, plastic bench, anti-slip rubber top.	PU leather, sponge, pearl wool, high density foam, steel frame	Aluminum Frame
Maximum weight	600 pounds	330 pounds	300 pounds	N/A	375 pounds	300 pounds	440 pounds
Product weight	10kg	12.7kg	3.9kg	4.78kg	12.6kg	N/A	21kg
Cost	$198	$299	$111	$79	$260	$169	$119

(Flybird, 2023; Reebok, 2023; Yes4all, 2023; Fiar, 2023; ViscoLogic, 2023; Prisp, 2023)

ABS and polypropylene are two plastics that are used for fitness equipment as well as luggage. Both plastics are considered environmentally inert and are more difficult to recycle than other types of plastics due to their higher melting points (Plastic Expert; Baleforce, 2021). ABS does not last as long since the plastic is more rigid and less flexible making it more likely to crack and break (Retlaw Industries; Kroeger, 2023). Design considerations can also be taken into account of allowing for separation between parts and avoiding coatings or overmolds that would make the product impossible to recycle.

Workout Mat

Workout mats or yoga mats are typically produced in the following materials: PVC (Polyvinyl Chloride), natural rubber, TPE (Thermoplastic Elastomer), NBR (synthetic rubber), PU, EVA, Jute, Cotton, Hemp, or Cork. The more natural materials that can biodegrade provide more opportunities for a circular economy but have shorter lifespans and less durability. Natural rubber being a good circular economy choice for the user group. The rubber provides cushion and stability, but can be

heavy and difficult to move around (Fitsri, 2021). TPE, like TPU, is a plastic combined with rubber and has similar sustainable and mechanical properties to TPU. TPE has more flexibility and is softer than TPU (Xometry, 2022).

Table 9: Benchmarking Yoga Mats

Brand	**Amazon Basics Yoga Mat**	**通用 Yoga Mat**	**BX BodyXtra Yoga Mat**	**Navaris Yoga Mat**
				
Material	TPE	Natural Rubber	PVC	Cork and TPE
Weight	998g	3.6kg	794g	727g
Cost	$43	$42	$36	$52

(Amazon Basics, Yoga Mat, 2023; 通用, 2023; BX BodyXtra, 2023)

Manufacturing

Free Weights

Choosing the right materials is only part of the solution to creating a sustainable product. Repairability and designing a product for disassembly are important to ensuring recyclability and increasing the longevity of products. Consumers need to be provided with information on how to disassemble their products for repair and information on which parts can be recycled. Responsible Consumption and Production is goal 12 of the UN's sustainability goals. There should be options from the manufacturer for providing spare parts, so the consumer is empowered to fix broken items (One Planet Network, 2022). These manufacturing methods of repairability can be used for the free weights which are not typically repairable products based on the current market offerings.

Workout Bench

Aluminum and steel, used for the frame of the workout bench, are highly recyclable materials and can be produced using recycled metals. This provides an opportunity to implement recycled metals as part of the manufacturing process and create programs to reclaim these metals. For instance,

Apple (2022) offers discounts to customers when purchasing new products if they bring in their older models. The company uses robots to extract metals and components that can be recycled to produce the newest model. The newer IPhone frames are made of 100% recycled aluminum due to these manufacturing processes. The company has also become carbon-neutral by implementing green-energy in all of their buildings and stores. They have greatly reduced their carbon emissions by implementing green-energy across their supply chain.

There are two main types of manufacturing that could be used to produce the steel or aluminum frame of the workout bench: extrusion or casting. Extrusion pushes the metal into a die to create a long metal shape. This method is inexpensive and cost effective. Casting would require molds to create the form of the metal and allows for more intricacy in the final part. To make this process more sustainable, reusable molds made of recyclable materials can be used. For instance, using a steel mold versus a disposable sand mold (Garbrian, 2020).

Workout Mat

The textile industry continues to evolve with new types of materials that change the way we use fabric, which improves both comfort and longevity. The industry has long used biomimicry to manufacture new types of fabric and materials (i.e. Velcro imitates burrs). Now processes for manufacturing textiles are working on developing fibers that don't need pigment, instead using nanotechnology like a butterfly's wing, reducing both energy and water needed to dye fabrics. Self-healing fabric is also in development at MIT based on the healing properties of crab shells. Fabric that can heal can greatly increase the longevity of a fabric without using synthetic materials (Cherny-Scanlon, 2014).

Figure 4: Robotic Fabric (Ham, 2021).

The company Mylo produces sustainable leather made of fungi (Mycelium) and uses biomimicry in the manufacturing process of their material. They grow the fungi in a green energy powered farm lab by mimicking the forest floor in its natural environment, which reduces deforestation in the natural world (Mylo, 2022). New types of fabrics are also being developed at MIT to include programmable fibers which can dynamically move, contain temperature sensors, and memory. The fiber is currently made of polymer and silicon, which is less sustainable, but it could provide opportunities such as tracking health and fitness performance in a way we were incapable of doing before. Since the fabric is intelligent there may be possibilities for separating materials in the future (Ham, 2021).

2.2.5 Benchmarking –Sustainability of Existing Products

Benchmark Sustainable Initiatives

As mentioned, there can be difficulty sourcing sustainable materials for certain fitness equipment while also maintaining durability, longevity, and comfort for the product. The fitness equipment industry has fallen behind in terms of developing products that contribute towards a circular economy. There are alternative ways to improve product sustainability without such as SportsArt's ECO-POWER product line which stores kinetic energy produced while working out and creates electricity. This reduces the carbon emissions needed to produce electricity. The company claims the machine can use 74% of the kinetic energy to create 22wH from an hour workout (Biofit, 2022).

Figure 5: Eco-Power(Eleiko, 2020).

The Swedish brand Eleiko which produces strength equipment has developed a sustainability plan which focuses on reducing their impact on transportation, waste, and energy. Their plan involved moving most of their production from countries like China and Latvia back to Sweden. They changed processes like adding a refunding program for their products packaging, as well as reusing pallets for their shipping instead of disposable pallets. The company also transitioned some of their materials, such as using recycled crumb rubber and PU as a better alternative plastic (Eleiko, 2020).

Figure 6: Eleiko Equipment (Eleiko, 2020).

The German company WaterRower/Nohrd designs sustainable exercise equipment primarily using wood, leather, and natural materials for their production. The company goes further than just using sustainable materials. They ensure that all the woods they use are from sustainably managed forests that are Forest Stewardship Council certified. This ensures that the woods they use are not contributing to environmental degradation (Nohrd, 2023).

Figure 7: Nohrd Bench (Nohrd, 2023).

2.3 Summary of Chapter 2

In conclusion, the primary user research provided insights into the target user group by providing a better understanding of seniors daily lives and what motivates them to participate in their daily activities. In addition to this, benchmarking on existing products has been conducted to better understand where the potential needs and gaps in the market are. In the following section the data collected during the user research phase will be analyzed.

analysis 03

The following chapter will discover the various needs of the user by using a variety of diagrams and maps to reframe and synthesize the primary and secondary research. In addition to this, a human factors ergonomic study will be conducted.

3.1 Analysis - Needs

This section outlines the needs and benefits not met by current products, latent needs, and categorization of needs.

3.1.1 Needs/Benefits Not Met by Current Products

There are a number of current needs not being met for equipment for seniors in the current market. There are no specific products that identify the issues seniors face with strength training and provide them with a targeted holistic solution that aids them in participating in physical activity. Current fitness equipment is primarily targeted towards younger adults and tends to be heavier, less comfortable, and may require movements that are not within the capabilities of adults over the age of 60. Sedentary seniors also require guidance on what types of exercises they need to do, how to perform them, and progressions to improve. These progressions must be incremental and at the seniors own pace. Other products that provide more casual fitness, such as the Ring-fit, are targeted towards a younger demographic through their digital adventure game interface, which may not appeal to an older demographic. These games also do not provide strength training for seniors and require dynamic movements, such as getting on and off the floor quickly.

3.1.2 Latent Needs

The fundamental human needs (FHN) of seniors is outlined in the chart below, based on Maslow's Hierarchy of Needs. The benefit statement lists the benefits that the final solution should include.

Table 10: Fundamental Human Needs Chart

FHN	Benefit Statement	Importance
Physiological Needs (food, water, shelter, rest, comfort)	Exercising keeps seniors healthy and mobile.	High
	Hand grips on equipment are comfortable to hold for seniors with arthritis.	Moderate
Safety Needs (security, safety)	Fall prevention features. Senior feels safe while exercising.	High
	Cost to entry is not too high.	Moderate
	Easy to use and set up. Needs to be all one package and connected. Needs to be reliable.	High
	Users need to be able to take their time and not rush exercises.	High
	No subscription model for exercise programs (secure with resources).	Moderate
Love and Belonging (relationships, friends)	Not feeling judged while exercising.	Moderate
	Belonging part of a community that exercises.	High
	Being able to watch someone perform the exercise before attempting it yourself.	High
	Users' friends participate in exercise so they will as well.	Moderate
	Feels social pressure to be a part of the group.	Moderate
Esteem (prestige, feeling accomplished)	Equipment is fun to use and enjoyable for the senior to exercise.	High
	Seniors' aches and pains are reduced from regular exercise.	Moderate
	Exercises goals to reach and improve health.	High
Self-actualization (reaching full potential, creative activities)	Can be creative with the exercise equipment.	Moderate
	Exercise is not too difficult to perform well.	High
	Fun games and rewards make the product motivating to complete and set-up the user for success.	High

3.1.3 Categorization of Needs

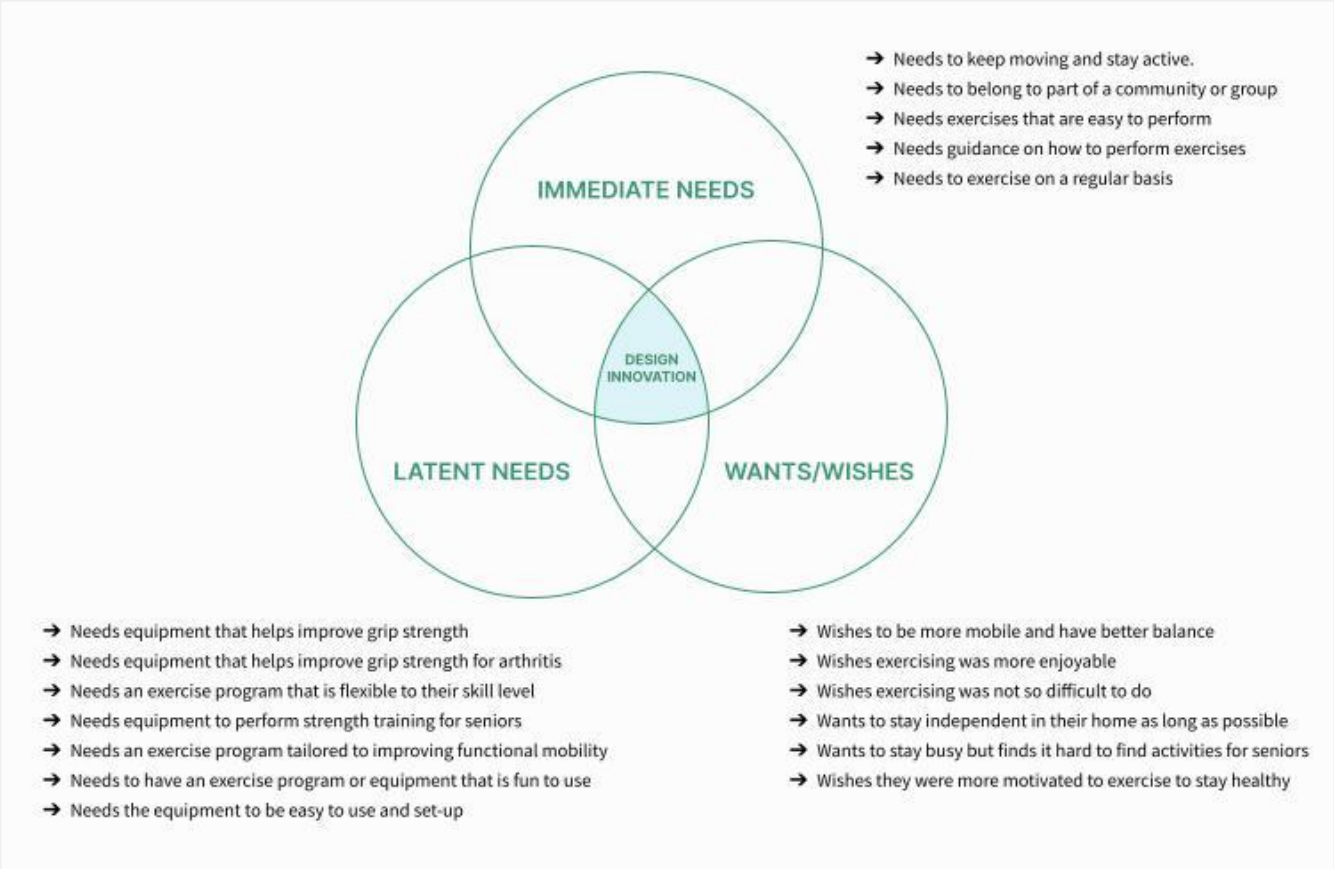


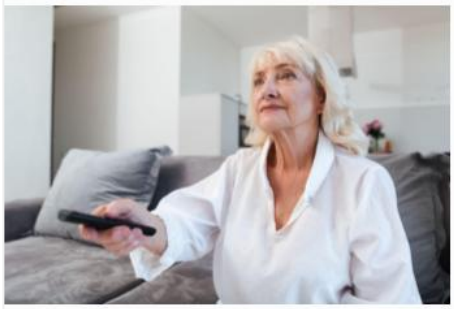
Figure 8: Categorization of needs

3.2 Analysis – Usability

Design maps help further the design process by synthesizing the information gathered through the primary research data collection. These maps help frame the user to better understand their motivations, needs, and experience. Design maps can help ensure that future design concepts are addressing the major pain points of the user and providing an adequate solution.

The following maps used to frame the user are an empathy map (to better understand the user persona), a journey map (to understand the users daily routine), and an experience map (to understand challenges in their routine and potential design ideas). Finally, a STEPVE map (Social, Technological, Economy, Political, Value, and Environmental) was produced to better understand the broader social context of the design problem (found in Appendix A).

EMPATHY MAP



65-75YR OLD SEDENTARY SENIOR

- **Feels comfortable staying inside at home**
- Partner passed away and she lives alone
- Has joint pains that keep her from being too active
- **Sits on the couch and watches TV to pass the time**

DO?

- Meets with friends once a week to play cards
- **Spends most of her time at home** watching TV, etc.
- Goes to volunteer once a week at a hospital
- **Does not exercise regularly** but will go on walks
- **Does not walk outside in winter** time - fear of falling
- Visits with her grandchildren once or twice a week

PAIN?

- Not exercising makes her joint pain worse
- **Not wanting to exercise alone** or by herself
- Not knowing what exercises to do when working out
- Prefers to do activities instead of fitness workouts
- **Does not feel accomplished when she exercises** like she does with other activities

SEE?

- **Some of her friends have fallen** and have been hospitalized after fall injuries
- She has older friends that have had steady declines in their mobility and now use wheelchairs
- **Sees friends with mobility issues not being able to maintain the same quality of life**

THINK & FEEL

- **Feels isolated** since her husband passed away
- **Worries about being too active and hurting herself**
- Intimidated to go to a gym or any exercise program with younger people
- She also worries about losing her mental state and keeping her independence

SAY?

- "I wish there were more opportunities to exercise to maintain my health"
- **"I am not interested in becoming a very fit person"**
- "It is difficult for me to meet new friends and find other friend groups to hangout with"
- "When my arthritis acts up its hard for me to feel motivated to do anything"

GAIN?

- Goal of creating an overall **better and healthier lifestyle**
- Exercising will lessen her pain and keep her more nimble
- She could gain a larger social circle if she was able to join programs designed for seniors
- Be able to understand what she needs to do to stay healthy and maintain mobility into her later years
- **Independence for as long as possible**
- A solution that is entertaining and not boring

HEAR?

- **That is important to stay active to keep her mobility**
- Doctor tells her that she is at risk for developing diabetes
- Her friends say that if they exercise too much they could injure themselves and make things worse
- **It's better to just stay inside in the wintertime so she doesn't slip an fall**

Figure 9: Empathy Map

3.2.1 Journey Mapping

JOURNEY MAP

	MORNING ROUTINE	GOES ON A WALK	VISITS FRIENDS	TAKES A NAP	NIGHTTIME ROUTINE	SHORT TERM	LONG TERM
USER GOALS	Preparing for the day and maintaining the household.	To get out of the house and get some fresh air.	Socialize and catch up with friends. Have fun.	Take a rest from the activities previously in the day.	Watches TV and prepares for bed	Wants to keep busy, entertained and relaxed in retirement.	Wants to stay in her home as long as possible. Wants to manage pain in joints as much as possible
USER ACTIONS	Gets dressed, goes up and down stairs. Cleans and tidies up the house. Eats breakfast	Goes outside and walks around the neighbourhood. Looks at neighbours' gardens	Drives to friends house. They sit inside and chat. They play cards together.	After going out she needs to take a nap to recharge. Lies on the couch and closes the blinds	Makes dinner, cleans up, goes up and down stairs. Watches TV then goes to bed.	Keeps relatively busy throughout the day and passes the time. Still relatively mobile despite low fitness levels. Does light cardio through walking.	Loses functionality and mobility since she is not maintaining their strength, balance, flexibility. Becomes less and less active.
USER THOUGHTS	"I find it difficult to go up and down the stairs" "Getting up from chairs takes a lot of effort"	"I like to look at other peoples gardens. Seeing the flowers brings me joy"	"I enjoy chatting with my friends and having some healthy competition with a card game"	"After seeing my friends I get so tired and need to take a break."	"I don't do much in the evening. I cook myself some dinner and walk some of my shows on my IPad"	"I am just trying to fill my days. I am always looking for something to do. It's harder to find things to do in the winter time"	"I wish I had been more active before I started to have more difficulties moving around,"
USER FEELINGS	Worries that someday she will need to move since she will not be able to get upstairs to her bedroom	Likes to go outside in the summer and spring. But cannot do this in the winter time. In the winter she is scared to walk outside.	Socializing makes her feel accomplished and makes her feel like her day was fulfilled.	Taking naps and breaks is necessary for her to make it through the whole day. As she has gotten older she is more tired and needs more sleep.	Likes to relax at the end of the day. She likes to keep up with the latest television shows.	She feels satisfied with her days and enjoys spring and summertime the most where she can be outside and there is more to do	She is unhappy with how she spent her time and feels she could have avoided her current immobility by being more active in her daily life.
PHOTOS							

Figure 10: Journey Map

3.2.2 User Experience

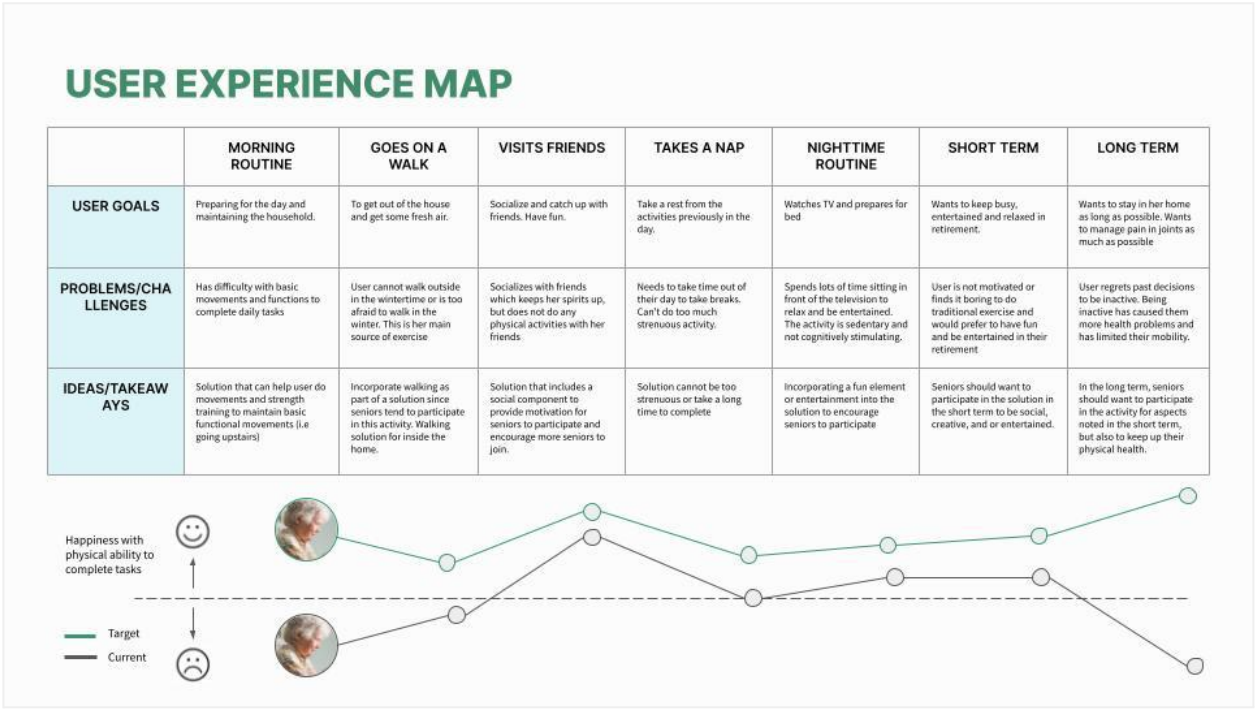


Figure 11: User Experience Map

3.3 Analysis – Human Factors

The following section will outline the human factors and the initial ergonomic study conducted for this project. The study consists of completing schematic diagrams of the proposed design solution (3.3.1) and a 1:1 scaled mock-up human scale study (3.3.2). The ergonomic study will focus on positions based on the functional movements required for seniors to perform:

- Grip positions on the handheld equipment
- Moving from standing to sitting positions with the bench
- Stepping up on the bench
- Movements on the floor mat

The anthropometric data that was used to develop this ergonomic study was sourced from *The Measure of Man and Woman* (2002). The data being referenced are for the 99 percentile elderly adult male and the 1 percentile elderly adult female. The data for elderly adults is based on the age ranges from 65-79 within the target demographic being researched for this study. As humans age they lose their height due to shrinking cartilage, primarily in the spine. Elderly men lose 5% of their height by the time they are 65 and elderly women lose almost 6%. This data is used for overall body dimensions related to the bench and floor mat. For the handheld exercise equipment, the data for

the 99 percentile adult male and 1 percentile adult female was used to determine the design ergonomics.

For this research there were four models produced to be tested for ergonomics. These elements were mocked-up to represent the 1:1 scale of the entire smart exercise equipment system.

Products Assessed
Workout Bench
Interactive Floor Mat
Handheld Workout Ring
Dumbbells 1. Versatile 2. Standard 3. Sculpted

The purpose of this ergonomic study is to determine the effectiveness of the current product design of smart exercise equipment for the target user group seniors aged 60-75. The study will analyze the full-bodied human interaction design (FBHID) of the products outlined above using human models to test the products, as well as graphical schematics. The report will identify three primary touchpoint areas that will be used for evaluation of ergonomics. This evaluation will aid in understanding and assessing human factors as well as any challenges the user may face when interacting with the products.

The three primary touchpoint areas that will be evaluated in this ergonomic study were chosen to reduce harm to the user and elevate their experience when interacting with the product:

1. Interaction with the bench (Legs, buttocks, hands, arms)
2. Floor mat (Legs, Foot)
3. Handheld Equipment (Hands)

The target demographic for the smart exercise system are seniors aged 60-75. This demographic was chosen since users in this group experience or start to experience loss of bone density and muscle mass which affects their functional mobility, increases their risk of injuries, and can lead to loss of independence (Colón, 2018). Users in this age group also experience a decline in their MVPA, which is critical for maintaining their health and muscle mass as they age (Statistics Canada, 2021).

The evaluation process used a full-scale ergonomic model of the smart gym system to be utilized for the user observation of the following:

1. Observe the user holding handles, sitting, and standing on the bench
2. Observe the user stepping up onto the bench
3. Observe the user standing on the floor mats in different formations
4. Observe the user interacting with the handheld workout ring
5. Observe the user interacting with the dumbbells

The results of the ergonomic study are outlined below. The ergonomic schematics illustrate the touch points of the 99 percentile elderly man and 1 percentile elderly woman using the smart gym equipment. The physical ergonomic model evaluation depicts the touch points with a human model who fits the parameters of the 99 percentile elderly man and a model that fits the 25% percentile elderly woman (or the 2.5 percentile young woman).

3.3.1 Product Schematic –Configuration Diagram

The ergonomic figures depicted in Figure 1 show the two percentiles being studied as part of the schematic. The measurements from these human percentiles will be referenced from the Measure of Man and Woman (2002) to determine the sizing of the ergonomic model. The stature of the 99 percentile elderly man is 71.8” and the 1 percentile woman is 54.7”.

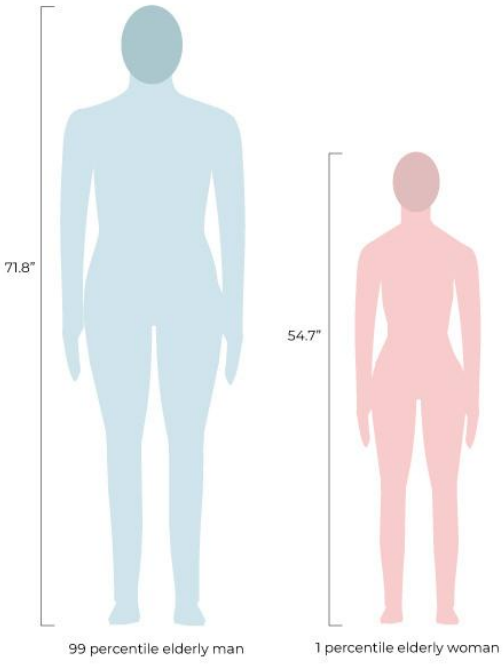


Figure 12: Ergonomic Percentiles

The schematic in Figure 2 represents the front and top view of the workout mat, as well as the top view of the workout bench. The range of exterior swing of the legs is 45 degrees. An angle was chosen within this range for an ideal distance for the legs to swing out to step onto the mat, between 15-30 degrees. The mat distance is 20" apart. The mat is also modular and can be adjusted to suit the users' preferences for a comfortable distance. The mats have a diameter of 13" which fits both the 99 percentile elderly man foot (11.1") and the 1 percentile elderly woman foot (7.6").

Left: front view of human percentiles on workout mat. Right: top view of workout mat with bench

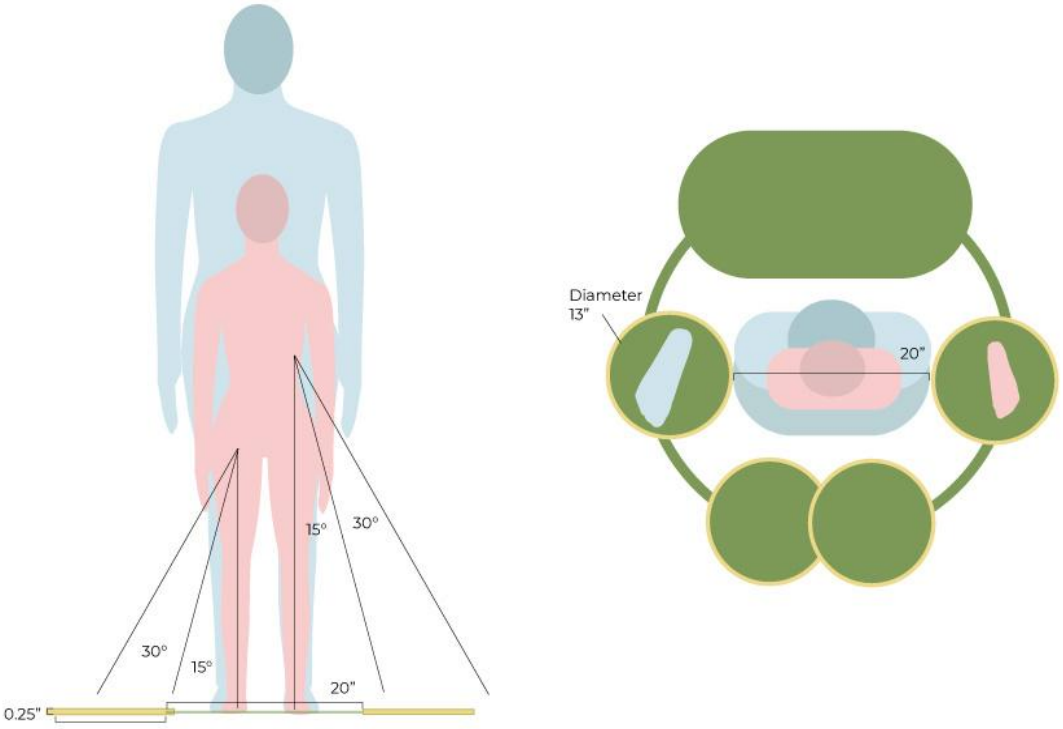


Figure 13: Schematic 1: Mat

The schematic shown in Figure 3 outlines the dimensions for the workout bench or step platform. Chair seat width is generally between 16-22". The bench is 30" wide to provide ample room for movement when using the bench as a stepping platform. The 99 percentile man hip width is 16" providing 7" of additional room on either side of the bench. In addition, the length allows for the user to pull the bench, with attached wheels, instead of lifting it up to move it around for storage. The 99 percentile man lower reach while standing is 38" and the 1 percentile woman lower reach is 30" to the floor. The 99 percentile man will need to slightly bend to pull the bench. Handrails are recommended to be between 30-34" from the ground.

The hand rests or handles are the arms on the side of the bench to assist the user into a seated position. The height of the hand rest is slightly lower than a recommended handrail height,

but are within the minimum reach height while stooping of 18". Standard chair armrest height is between 7.5-10". The 1 percentile seat height is 14" with the assistive hand rest height of 10", which brings the total height of the hand rest to 24". Both users will need to bend into a slight squat position to grab onto the hand rests.

The bench seat depth is 15" to accommodate the 99 percentile elderly man whose buttock to front of abdomen measures 14.5". The 1 percentile elderly woman buttock to abdomen is 7.1" and the maximum seat depth for this user is 16".

The seat height is adjustable to provide an appropriate height for each user. The 1 percentile woman seat height is 14" and the 99 percentile man is 18.7". The minimum height the seat will adjust to is 7" for the step platform.

The handles measurement grip handles are based on the recommended guidelines of between 0.875-1.25" in diameter. The opening for fingers under the handle (1.5") fits the 99 percentile elderly man finger thickness of 0.85".

Left: Side view of bench used as step platform; Middle: Front view seated on workout bench; Right: Side view seated on workout bench

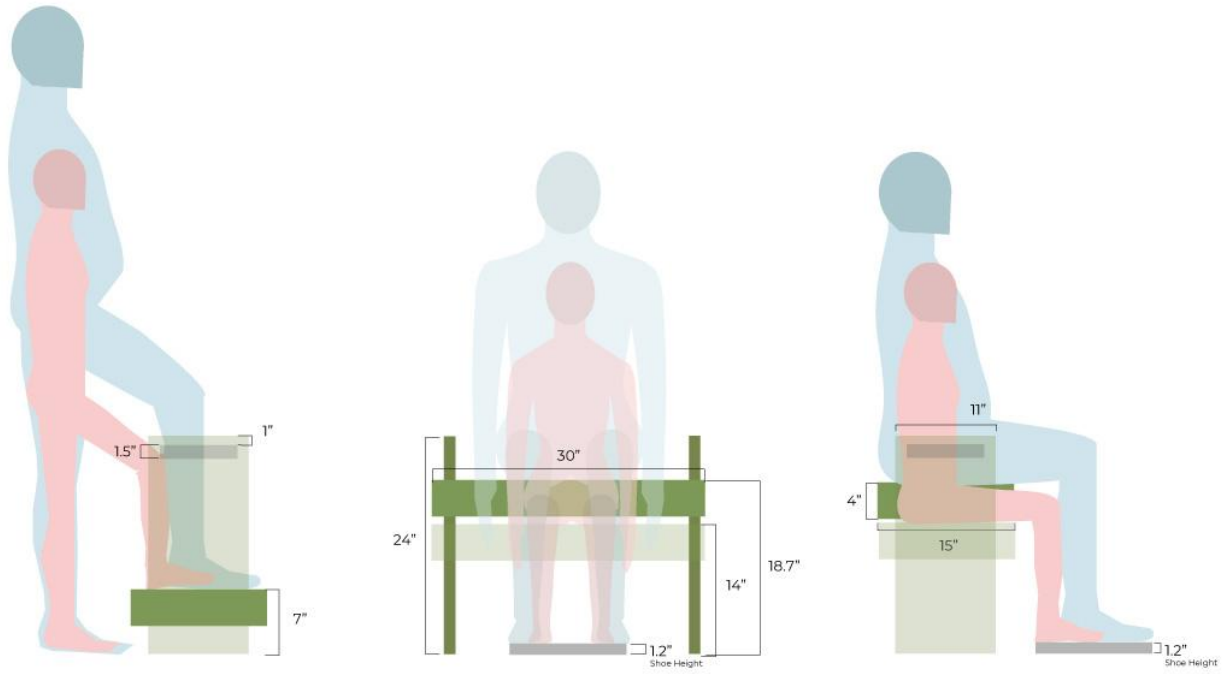


Figure 14: Schematic 1: Bench

The final schematic depicts the handheld workout equipment: the dumbbell and the workout ring. The diameter of both sets of handheld workout equipment is 1.5" which is recommended for ball or cylindrical grips and is within the optimal grip range of 1.25-1.5". This grip diameter fits both percentiles being studied in this report. The larger end of the grip range was

selected to provide seniors with weak grips or arthritis a more stable surface area to hold onto. The hand grip area on dumbbells studied in this report is a minimum of 4.5” wide. This accommodates the large hand of the 99 percentile elderly man whose grip width is 3.7”. The diameter of the workout ring is based on the shoulder width of the 1 percentile woman, which is 12.7” wide. This allows the woman to hold the ring in front of her, without her arms being too spread apart, and use the resistance ring correctly. The ring fits within the chest area dimensions of the 1 percentile elderly man (12.9”)

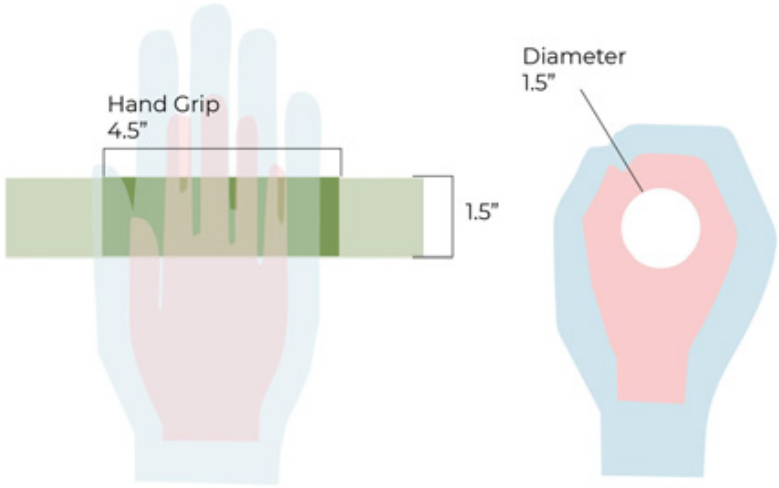


Figure 15: Top Left: Front view dumbbell grip; Top Right: Side view of handheld grip

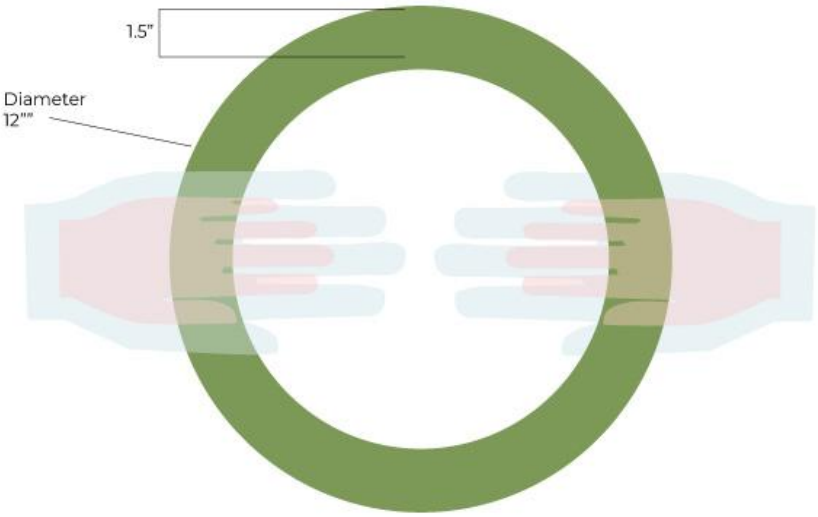


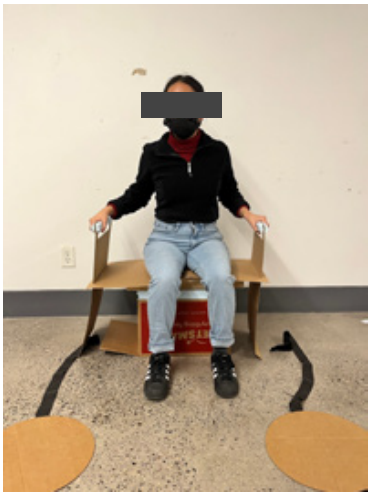
Figure 16: Schematic 1:Workout ring

3.3.2 Ergonomic - 1:1 Human Scale Study

The following section will show the results of the physical ergonomic study based on the 99 percentile elderly man model and 25 percentile elderly woman model (stature 49”). The section will also provide analysis, limitations, and conclusions of the 1:1 scale ergonomic study.

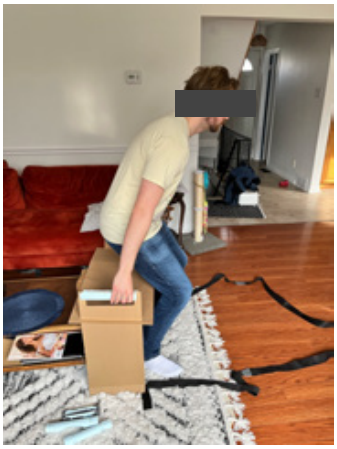
Table 11: Ergonomic Study

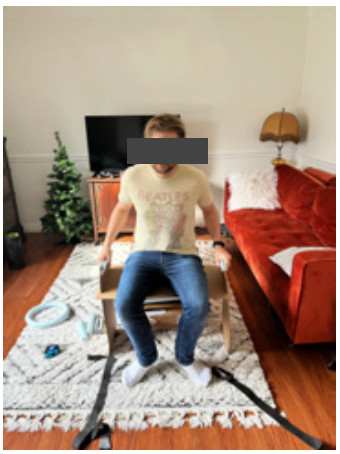
Sitting and Standing on Workout Bench
The seat height was adjusted for each percentile (14” and 18.7”). The first ergonomic test was sitting and standing on the bench. The 25 percentile woman had no difficulty getting seated. Although, the handles were a little high once in a seated position. There were no issues with the height of the hand rests or seat height for the 99 percentile man.
25 percentile woman
 

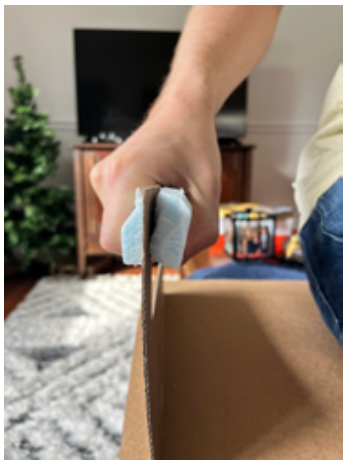




99 percentile man

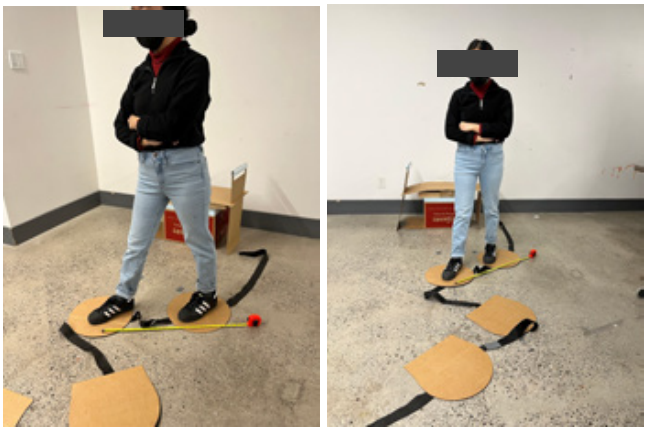


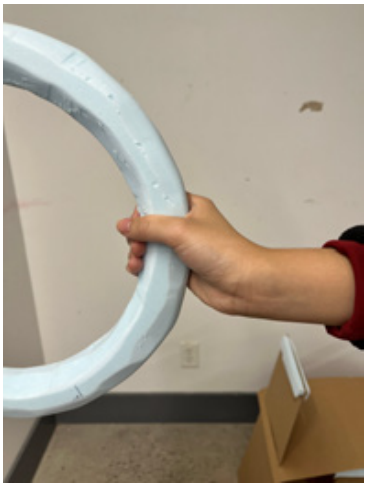
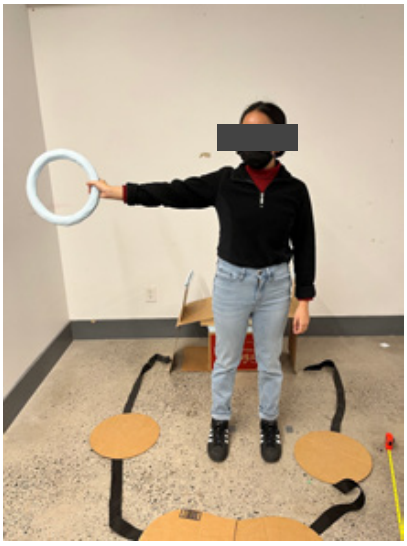
Stepping up on Workout Bench
The step height of 7” inches was accurately dimensioned for both percentiles. The handle was in the correct range for the 25 percentile woman. The handle required the 99 percentile man to bend far over to reach it. This handle may be too low for repeated use while using the bench as a stepping platform for the 99 percentile man.
25 percentile woman

99 percentile man

Standing on Floor Mat Formations
The floor mats can be arranged in any formation that the user requires, but the mat was tested to determine ideal distances. It was discovered that 20” distance width wise and 9.5” front-to-back were comfortable for both percentile ranges.
25 percentile woman



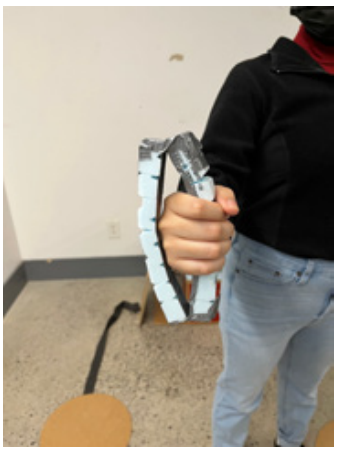
99 percentile man

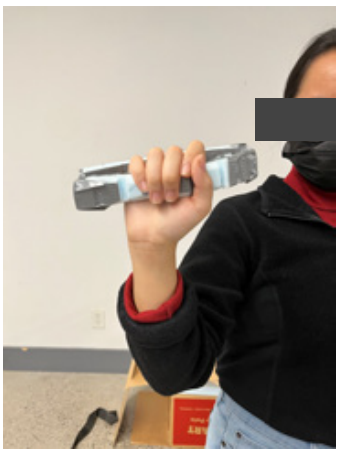
Workout Ring Grip
The workout ring dimensions were very successful with both percentiles. The ring fit comfortably in each percentile's hands and was a comfortable diameter for both percentiles to hold.
25 percentile woman
  
 

99 percentile man



Dumbbell Grip
Three dumbbell forms were tested to determine the ideal ergonomic grip. The sculpted grip (Grip 3) was unsuccessful with both users finding the sculpted dumbbell uncomfortable to hold despite the grip fitting well in both of their hands. The other two grips were successful. The cylindrical grip was comfortable for both users and fit the dimensions of their hands. The versatile grip (Grip 1) was 1.5” wide 1” deep when held from the exterior and 1” wide 0.5” deep when held from the interior. Both users found these grips comfortable to hold. The 99 percentile male expressed that the interior grip was very comfortable.
25 percentile woman
Dumbbell Grip 1: Versatile





Dumbbell Grip 2: Standard

Dumbbell Grip 3: Sculpted

99 percentile man

Dumbbell Grip 1: Versatile

Dumbbell Grip 2: Standard

Dumbbell Grip 3: Sculpted


3.3.2.1 Analysis

The dimensions studied in this report, as seen in the schematics in Figures 2-4, were chosen because they are the primary touchpoints of the user with the smart exercise equipment. The movements the user most commonly engages in with the equipment are sitting, standing, using the bench for support, and using the handheld equipment. A detailed description of the judgements for each dimension used on the mock-up developed for this study can be found under the section *3.3.1 Product Schematic –Configuration Diagram*.

The workout bench's overall size of the seat width and depth, as well as the adjustable heights for each percentile and step platform were successful for the percentiles studied. The arm

rests or handles were in general effective but did not always work as intended. The handle's height was set at 24” primarily based on a number of factors including standard handrail recommendations, standing and stooping reach of each of the percentiles, and standard seat heights. The handle height had shortcomings for the elbow height of the 25 percentile woman once she was sitting on the bench. The handles were a little too high for the 25 percentile women while seated. For the 99 percentile man the handles were too short when trying to use them as support for the step platform. In the future, there should be consideration of an adjustable handle/armrest for seniors to use for support.

The floor mat sizing worked well especially the 13” diameter of each mat which comfortably fit both percentiles foot size. An insight that was discovered during the study was that both users felt comfortable with the mats a similar distance apart (20” wide and 9.5” front to back). This allows for the possibility of the design being more standardized than it is currently. There is the possibility to still allow for modularity with more restrictions on distance and to reduce tripping hazards.

The workout ring was very successful in being a comfortable size for both percentiles to hold. The dimensions from the shoulder width of the 1 percentile elderly woman (12.7”) and the chest of the 99 percentile elderly man (12.9) were used to inform the overall diameter of the ring at 12”.

Finally, the dumbbell tests provided insights into a different direction the weights could take with a versatile weight that allows for two different grip types. There is the possibility for the larger grip on the exterior (1.5” wide 1” deep) that could also provide some resistance hand training for users with arthritis. The interior grip (1” wide 0.5” deep) provides the user another option which allows for security when holding the weight.

3.3.2.1 Limitations and Conclusions

The primary limitation of this ergonomic study was that a 1 percentile elderly woman model could not be used for the 1:1 human scale ergonomic study. This leaves the possibility that some design decisions will be made that do not consider or are not effective for the 1 percentile elderly woman. The critical ergonomic dimensions that affect the proposed product design are:

- Providing seniors with security while exercising (handle support and bench)
- Ensuring that the equipment provided does not increase risk of falling for the user (i.e floor mat)
- Providing seniors with ergonomic handheld exercise equipment that is easy to hold and use for weak or arthritic hands

- Giving seniors options to adjust their equipment to suit their body type and skill level (bench seat adjustment).

3.4 Analysis – Aesthetics & Semantic Profile

There is no precedent specifically for seniors exercise equipment for aesthetics and semantic profiling. Traditional exercise equipment for younger adults looks strong, tough and robust. The colours of the products are generally darker colours that look slightly intimidating and look like they are to be used by an individual who is very serious about exercising. The equipment also tends to look more functional and is not always very stylized. For example, gym machines can look very mechanical and industrial. These types of aesthetics and semantics will be avoided for the design of this project since it seeks to disassociate with traditional fitness and gym culture. The design instead seeks to provide a space for seniors to feel comfortable and not judged for their lack of physical fitness or technique.

3.5 Analysis –Sustainability: Safety, Health and Environment

The materials Silicone and TPU provide the greatest comfort and improve the ability to grip free weights. Both these materials are non-toxic, environmentally inert, and easy to clean. Both materials do not pose any health threats to the user after production and are food-grade safe. TPU and natural rubber provide these same benefits to the user for the smart floor mat. Natural rubber contains latex which could cause allergic reactions in users of the product. Steel or aluminum are good sustainable options for the frame of the bench since they are fully recyclable and do not pose any health risks to users. CO^2 emissions are produced in the production of the materials used in this project, which can affect the health of many individuals (Anderson, 2022). SIlicone and TPU are both petroleum based materials (Paleviciute, 2020). The production of 1 tonne of silicone is responsible for 5 tonnes of emissions (Anderson, 2022). Covestro has developed a TPU material (Desmopan) that is able to use CO^2 as part of its production process, reducing the total emissions produced (Bioplastics, 2018).

There are many safety considerations that need to be taken into account when designing fitness equipment for seniors, which may be in conflict with sustainability goals. Comfort and a non-slip coating are important features to provide safety for the senior user when holding the free weights, due to their age and weaker grip strength. Seniors need to feel stable when standing and moving on the floor mat. They need to feel secure that they will not slip and fall and if they do fall the mat provides some cushioning. Using lightweight materials for the bench will aid users in being able to move the seat around and maneuver the product around their home or in a community center.

More natural materials, such as natural rubber, can provide some benefits (like being non-slip), but have disadvantages (like being too heavy) in comparison to less sustainable materials (like TPU). In regards to the frame of the workout bench, steel may be a less desirable choice since the metal is heavier than aluminum. Steel may make it more difficult to move the fitness system and to store it versus aluminum.

3.6 Analysis – Innovation Opportunity

This section will help understand the innovation opportunity using a needs analysis diagram and a desirability, feasibility and viability chart.

3.6.1 Needs Analysis Diagram

Table 12: Roots of Cause Diagram

Problem	Most seniors are sedentary and live inactive lifestyles
Why?	Seniors do not see how exercising will benefit them since they are older.
Why?	Seniors do not want to workout alone and are afraid to join a group.
Why?	Seniors do not find exercise entertaining or enjoyable.
Why?	Seniors are afraid exercising will injure them or make them fall.

3.6.2 Desirability,Feasibility & Viability

Table 13: Desirability, Feasibility, Viability Diagram

Desirability	Seniors are not interested in traditional fitness or exercise. Seniors are interested in creative or social pursuits. This user group understands that physical exercise is important to promote healthy outcomes but is not motivated to perform tasks that are not interesting, entertaining or pleasurable. A product that provides interest, social interaction, and creativity while maintaining healthy living as a by-product will help to engage seniors.
Viability	This product breaks into a market that is being underserved for a vulnerable population where physical activity is important to maintain quality of life and health. There are few products on the market currently that address seniors' needs for workout equipment and engaging fitness activities. There is also a direct cost-savings for the Canadian government to fund programs to support these devices since they will improve the overall health of the senior population reducing stress and cost on the public healthcare system.
Feasibility	The technology that will be used to develop a solution for this design project exists since there is precedent for gym equipment, gaming technologies, ergonomics for seniors, and smart connected devices. This makes the design very feasible as long as conventional manufacturing methods are adhered to.

3.7 Summary of Chapter 3– Defining Design Brief

The design maps were used to help combine and amalgamate the use needs, user pain points, and ideas collected from the primary and secondary research. The data is presented in a way that helps develop a framework or picture of who the user is and how a design solution could be implemented to improve their quality of life. The following needs/wants that will be considered as part of the design solution:

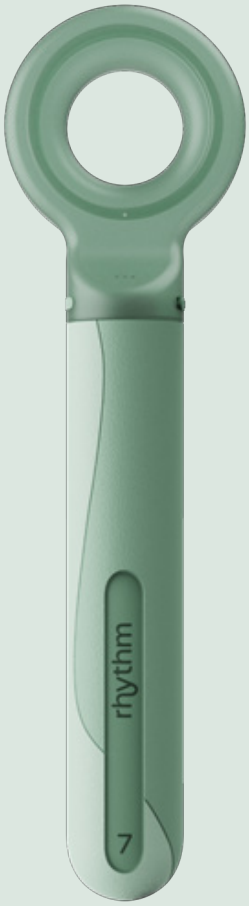
1. **Routine:** Seniors like routines and activities that they can fit into their life daily. For example, doing household chores was a routine activity that some seniors mentioned doing. “It gives me routine”. The primary research discovered that seniors like to have their activities be routine and adding this element may increase their ability to continuously engage with physical activity.
2. **Social Time:** Seniors like to be able to connect with others. This was a primary motivation for some seniors to exercise. One user discussed how they stopped exercising because they lost their workout partner. Social interaction and being part of a community is a huge factor for seniors to engage in activities and reduce social isolation.
3. **Fun/Entertainment**: Many seniors discussed being bored as a reason not to exercise. Seniors did not find the task as enjoyable or entertaining as other past times, such as watching television. Lack of interest was one the main factors affecting seniors' engagement in physical activity. The proposed design solution must implement elements of play or fun to keep the users’ interest and allow them to feel rewarded by participating.
4. **Creativity**: Activities that allow them to be creative or express themselves such as gardening or dancing. Activities that allow for creativity are more fulfilling for seniors. One senior said, “Music inspires me.” Creativity is another factor that provides feelings of accomplishments and purpose to the target demographic.
5. **Staying Physically Mobile**: Some seniors discussed staying active or exercise as a reason to do certain activities. “Stay active (mentally & physically), enjoy the competition of golf.” The design should improve or maintain the users’ functional mobility. Seniors see the value in physical activity and understand its benefits. Crombie et al (2004) found that 95% of their participants (N=1064) were aware of the benefits of physical activity. This benefit combined with fun and creativity will provide seniors with a reason to stay active. The final solution should provide seniors with the ability to maintain their functional mobility.
6. **Weather Impacting Exercise Routines**: Seniors need a solution that they are able to use all year round despite the weather, “I walk outside in the summer months, but now since the weather is colder, I do my 5 miles walking around the kitchen table in my family room in the basement.” The solution should provide the opportunity for seniors to workout indoors so

they can exercise all year long.

7. **Safety:** Research has shown that seniors are concerned about falls and injuries from being physically active or participating in too much physical activity, despite physical activity causing only 4% of fall injuries in seniors (Public Health Agency of Canada, 2014). Providing seniors with safety features such as somewhere to sit or something to hold onto while they exercise will allow them to participate in exercise without fear of falling. This will also allow them to be more confident in their movements so they can eventually exercise without the help of aids.
8. **Comfort:** Seniors should feel comfortable with all of the equipment ergonomically and be provided with grips and seating that fits their bodies. Seniors already experience discomfort from body aches, joint pains, and other physiological issues due to their age. It will be important to provide them with a solution that is as comfortable as possible to avoid rejection of the product due to increased discomfort.
9. **Adjustable:** In the same vein as comfort, the design should be adjustable to fit seniors' various body sizes but also to accommodate different levels of confidence while exercising. In addition, the difficulty level of the exercise routines should be adjustable to different ability levels to reduce seniors from abandoning the product.
10. **Friendly:** The design should appear friendly in its aesthetic and appear different from typical gym equipment, which is robust, strong, and rigid in its appearance. Seniors need to feel that the product is not intimidating, rather that it is casual and fun.

design development

04



4.1 Initial Idea Generation

4.1.1 Aesthetics Approach & Semantic Profile

The aesthetic approach for this report was to embody the goals of the design. The goals, outlined in the design brief (see section 3.7), were to design equipment for seniors that provided them comfort, safety, creativity, and an aesthetic that was friendly and inviting. To provide this visual cue to the users images were selected with rounded curves that appeared soft and gentle. The design will be smooth rather than sharp to provide a sense of security and safety. Aesthetics that use brighter colours and interesting shapes to signify to the user that the product is intended for creativity and fun. The design will be simple and uncomplicated to show that it is easy to use and interact with. This is important for seniors who will need the device to be intuitive to understand due to aging and their experience with technological devices.

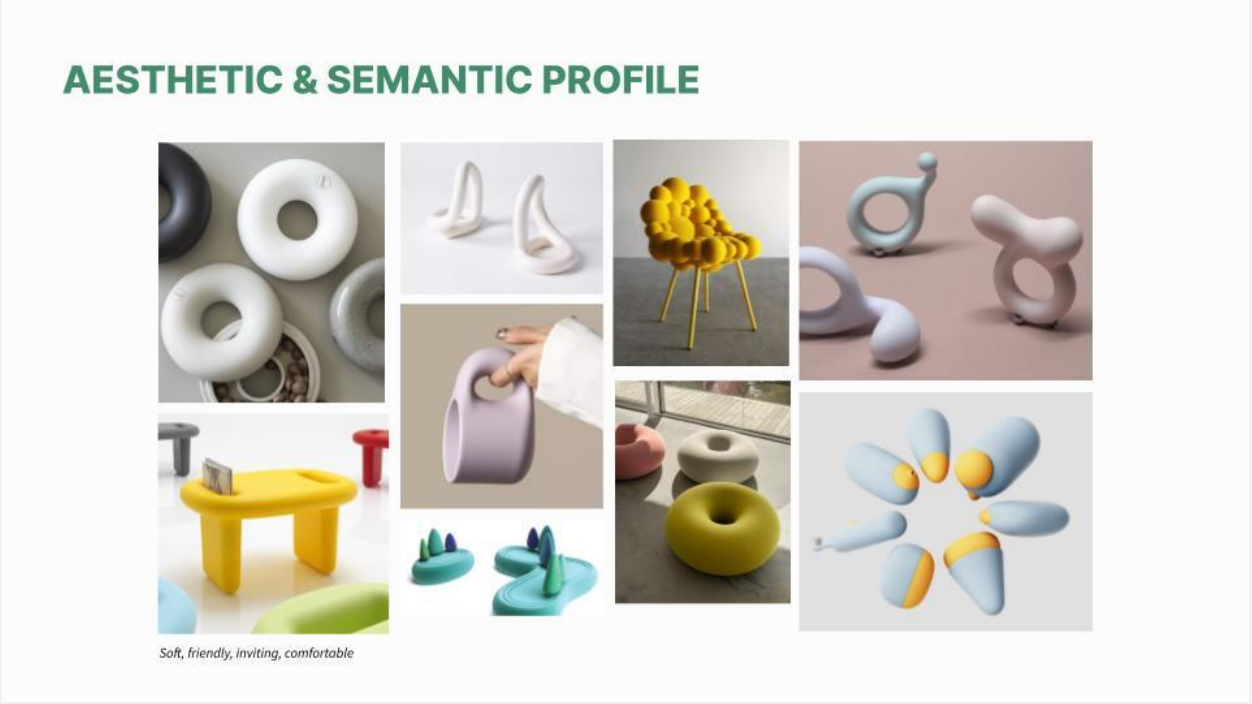


Figure 17: Aesthetic & Semantic Profile

4.1.2 Mind Mapping

At the end of the research phase and the beginning of the idea generation phase, mind mapping was used to explore different potential solutions to the design problem. The first mind map was used to understand and summarize the pain points and needs to start making connections and develop preliminary solutions. The second mind map, was an iteration on the first that honed more in on the specific needs, which would develop into the design brief (section 3.7) of the user and potential

solutions for each of those needs. This method helped to develop distinct potential solutions that were generated in section 4.1.3 Ideation Sketches.

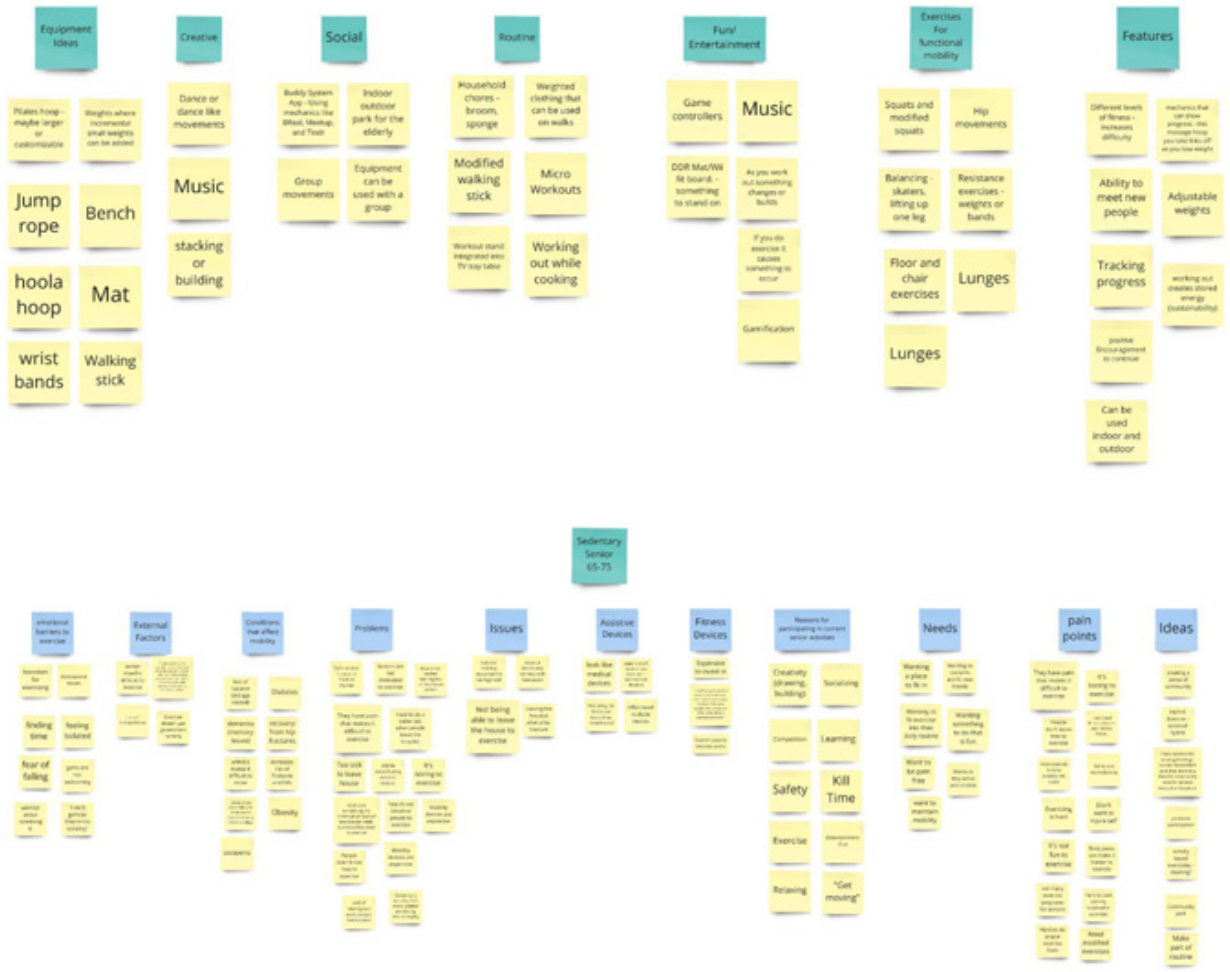
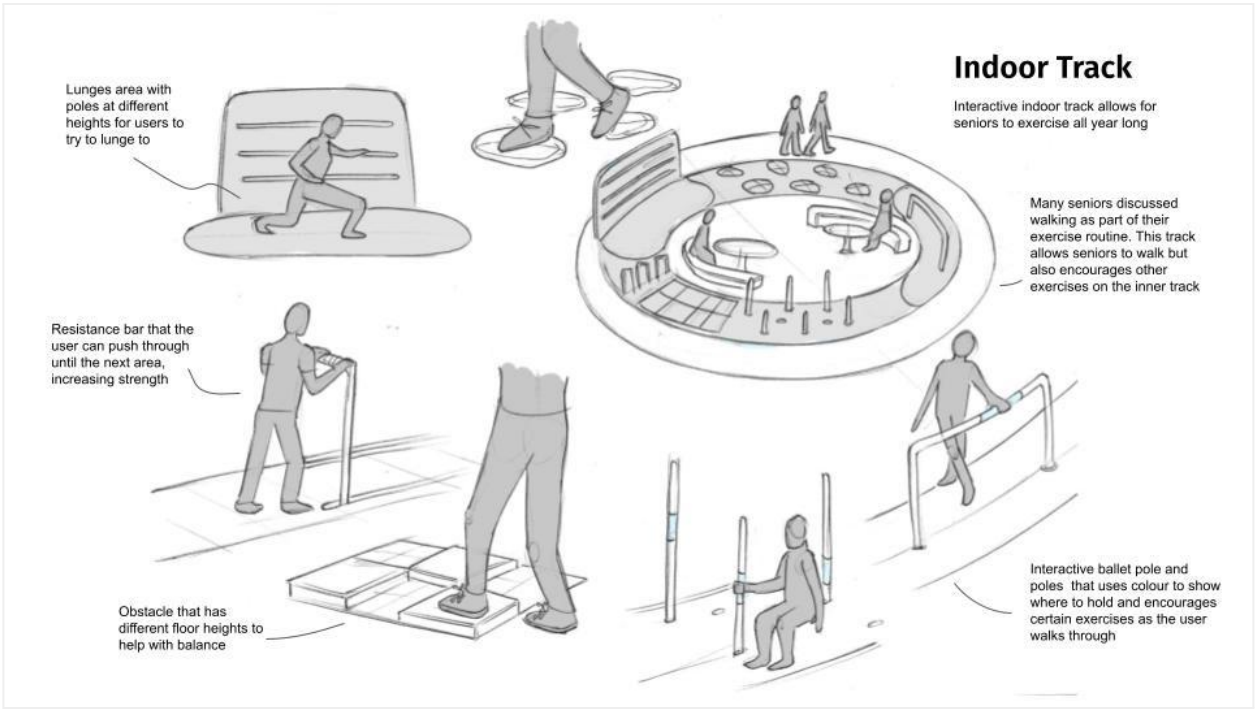
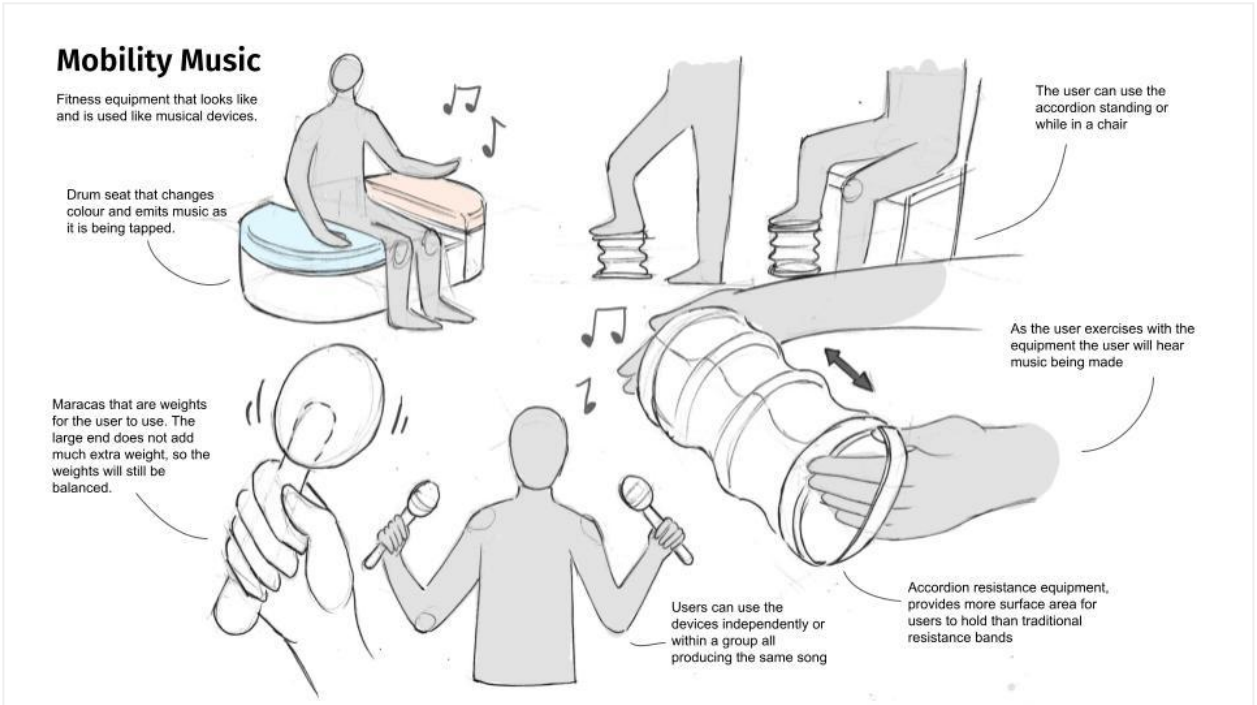


Figure 18: Mind Mapping

4.1.3 Ideation Sketches

The following are ideation sketches that were generated from the mind mapping phase of the design project. At this stage in the process the objective was to develop as many unique directions as required to determine the best possible solution.There were six distinct ideations generated, in detail, as solutions to the problem definition. The six solutions are: an interactive indoor track for seniors, musical workout equipment, interactive workout equipment, a ladder that trains users to practice functional movements, equipment that fits into a users daily routine, and a park for seniors. The focus for this stage of development was on the functionality of the design and how the design could serve the user needs outlined in section *3.7 Design Brief*.


Indoor Track
Interactive indoor track allows for seniors to exercise all year long
Lunges area with poles at different heights for users to try to lunge to
Many seniors discussed walking as part of their exercise routine. This track allows seniors to walk but also encourages other exercises on the inner track
Resistance bar that the user can push through until the next area, increasing strength
Obstacle that has different floor heights to help with balance
Interactive ballet pole and poles that uses colour to show where to hold and encourages certain exercises as the user walks through


Mobility Music
Fitness equipment that looks like and is used like musical devices.
Drum seat that changes colour and emits music as it is being tapped.
The user can use the accordion standing or while in a chair
As the user exercises with the equipment the user will hear music being made
Maracas that are weights for the user to use. The large end does not add much extra weight, so the weights will still be balanced.
Users can use the devices independently or within a group all producing the same song
Accordion resistance equipment, provides more surface area for users to hold than traditional resistance bands


Routine Equipment
Equipment that can be integrated into daily house cleaning or cooking.
Mat that encourages micro activities when you stand onto it
Cleaning sponge weight, to add strength training while cleaning dishes or cleaning the counter top
Weighted smart broom. The broom asks for different movements while cleaning (i.e. side step). The broom is also weighted to provide more strength training.
GOOD
Progress can be tracked and shared with friends. Users can also participate in cooperative fitness goals between a group of friends. This encourages social connections.


Gliders that are on ground level. As you exercise the flowers will "grow" to show progression. Multiple users can work towards the flowers growing.
Picnic tables are on the edges of the park to give users a place to rest and chat
Roof has solar panels to power the park equipment. User energy from exercising is also stored
Low impact bike that shows how long you have been riding with colour on the wheel
Community gardens in raised flower beds surround the park. This encourages seniors to come to the park to work on the garden
Wall with interactive puzzle games. Where users must use their bodies to complete the challenges
Resistance bars pull up and down.
Mobility Park
Interactive park for seniors with low impact equipment.

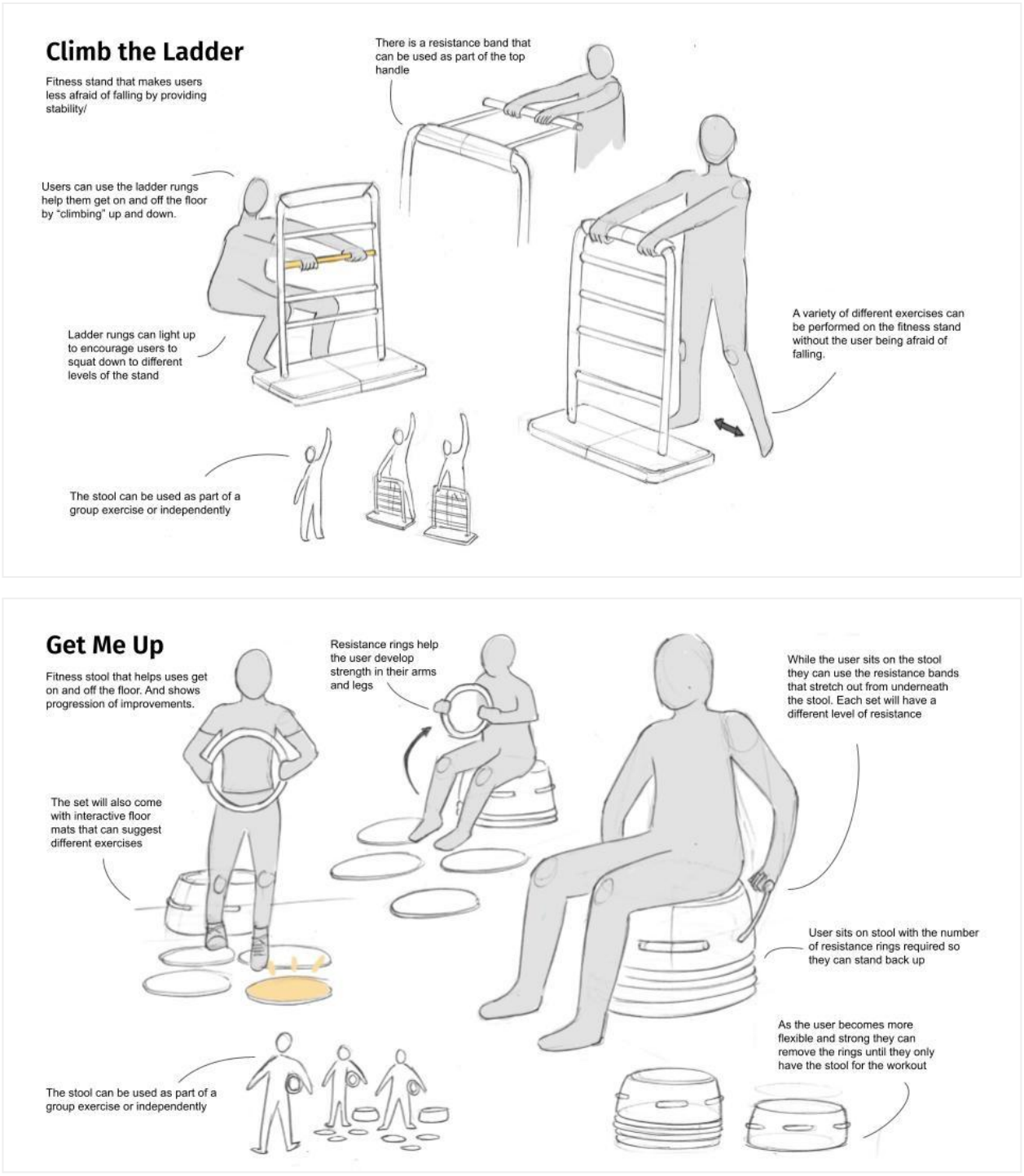


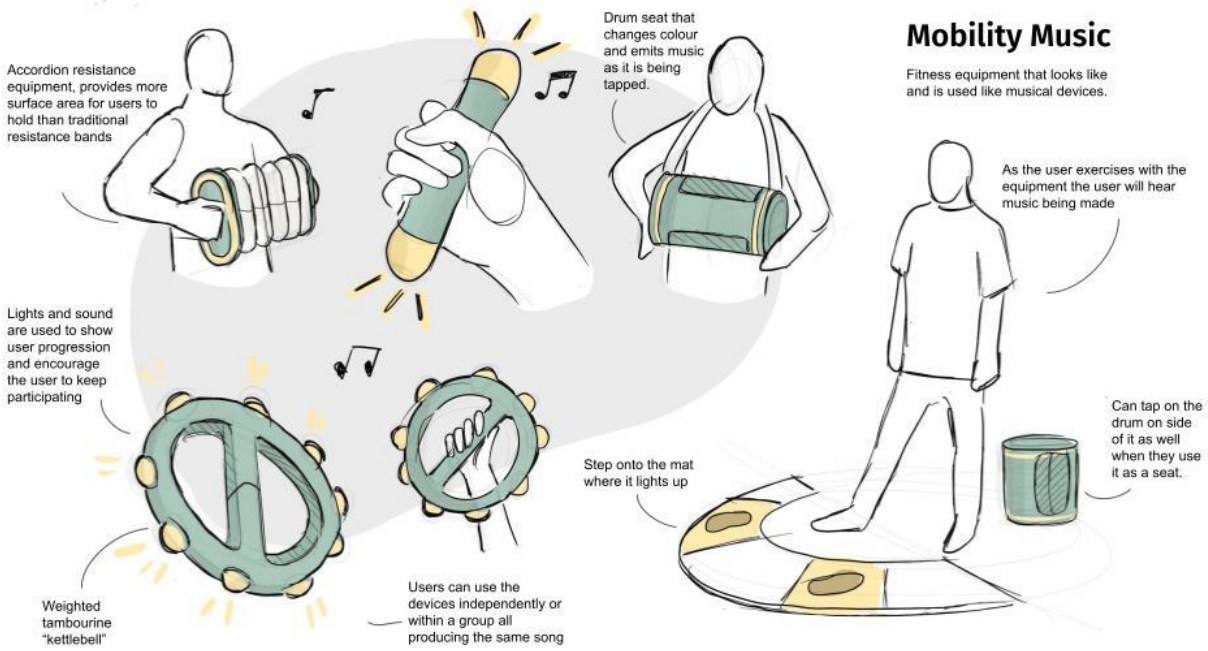
Figure 19: Ideation Sketches

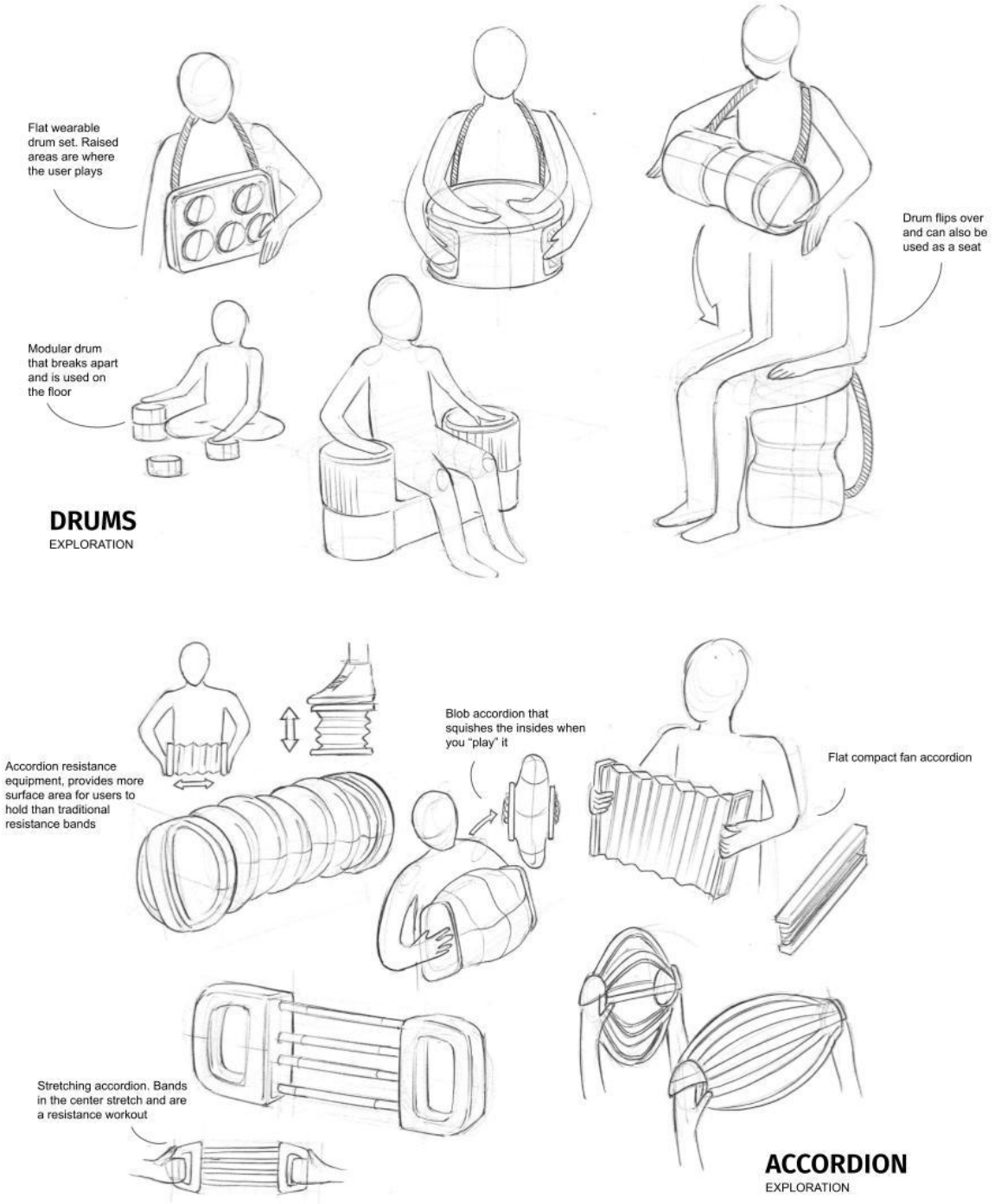
4.2 Concept Exploration

There were three concepts from the ideation phase that were selected to move forward to further determine which solution would be the final direction for the design project. The three concepts that were selected were the musical workout equipment, the interactive workout equipment, and the indoor track for seniors. These concepts were selected since they best met the needs of the user and had the most potential to create an original, usable, and interesting design.

4.2.1 Concept One

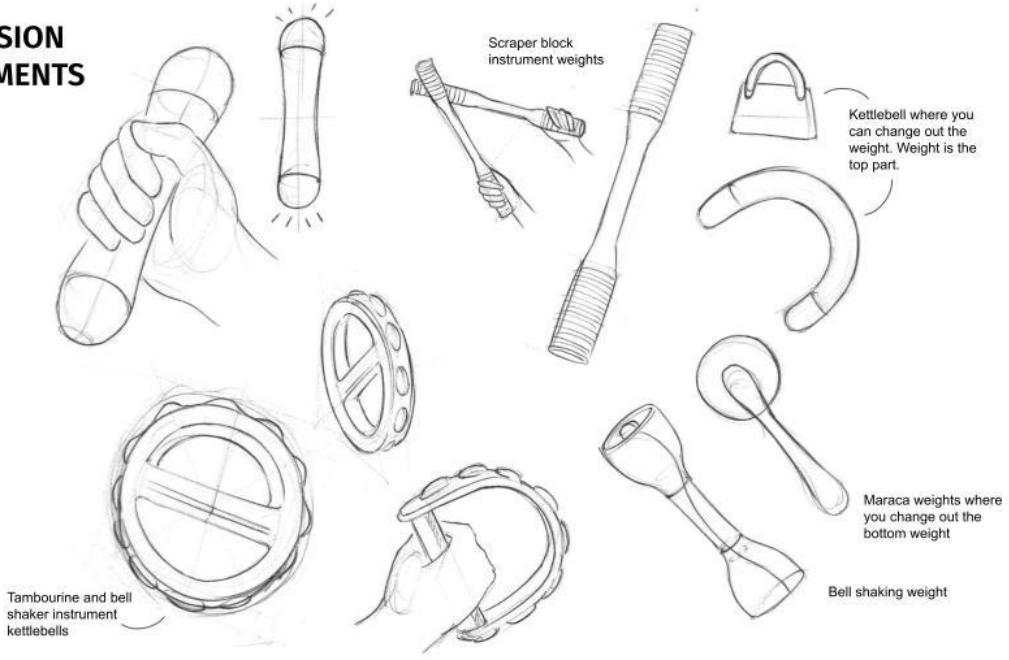
The first concept that was selected, Mobility Music, is fitness equipment that looks like and is used like musical instruments. The instruments would allow the user to use the equipment in a similar way to traditional exercise equipment but would be more fun and inviting. The fitness equipment would be responsive as the user interacts with it through lights and playing music. The devices can be used individually or within a group. The devices allow the user to be social, have fun, and be creative while they exercise.

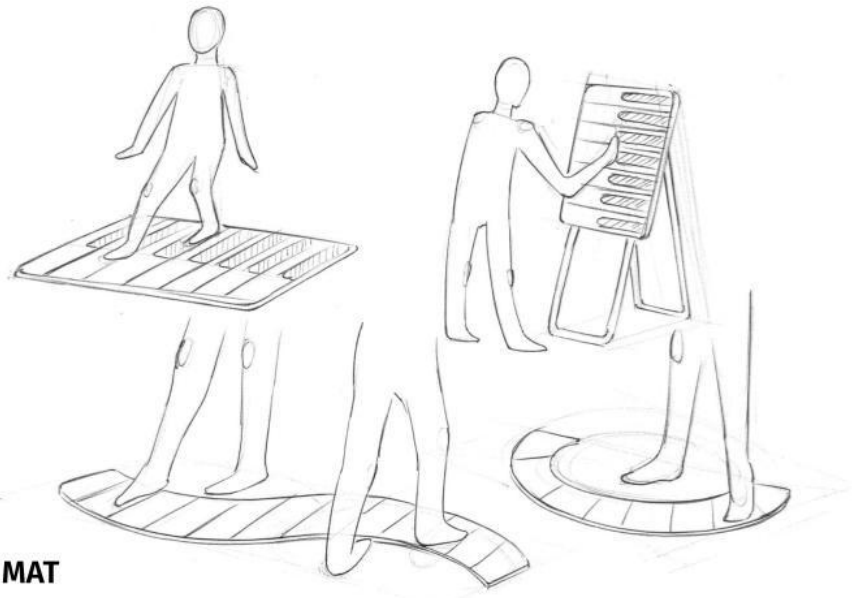



Flat wearable drum set. Raised areas are where the user plays
Modular drum that breaks apart and is used on the floor
Drum flips over and can also be used as a seat
DRUMS
EXPLORATION
Accordion resistance equipment, provides more surface area for users to hold than traditional resistance bands
Blob accordion that squishes the insides when you "play" it
Flat compact fan accordion
Stretching accordion. Bands in the center stretch and are a resistance workout
ACCORDION
EXPLORATION

PERCUSSION INSTRUMENTS

EXPLORATION



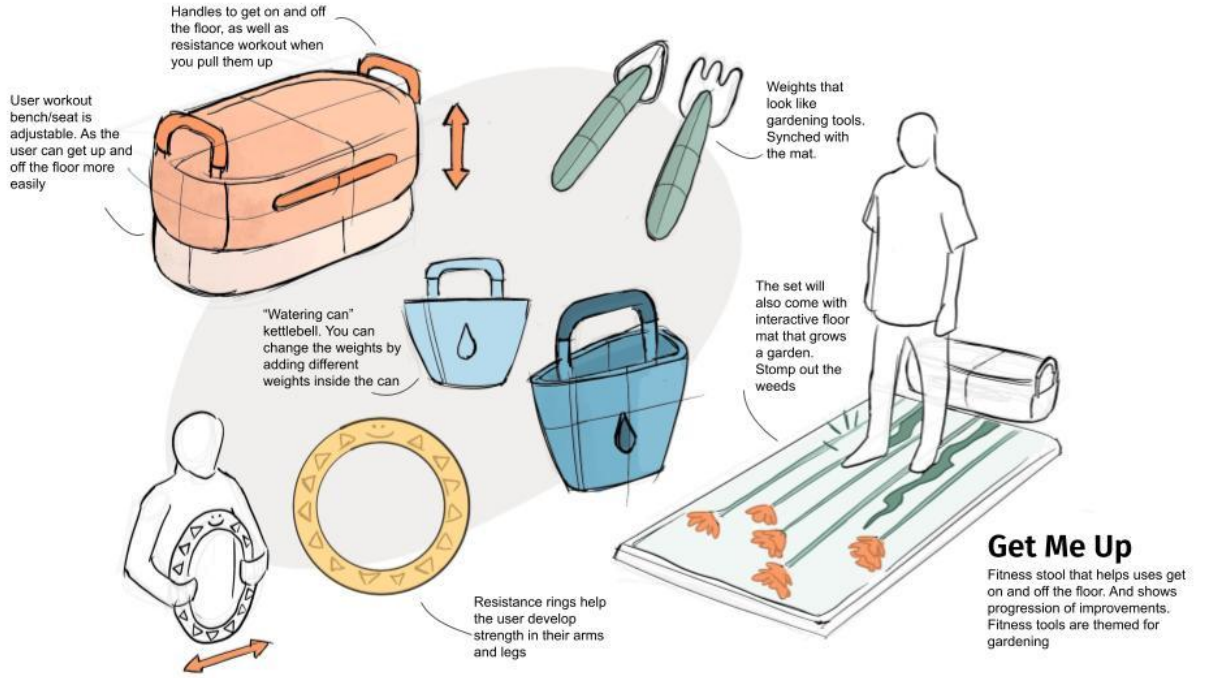


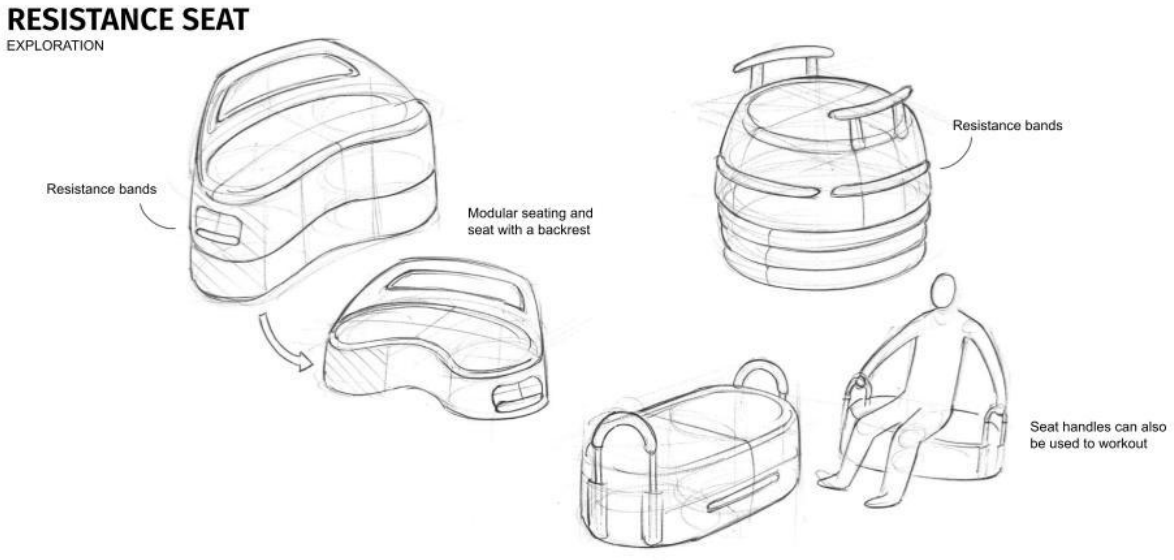
PIANO MAT

EXPLORATION

4.2.2 Concept Two

The second concept is the evolution of the interactive fitness equipment from the ideation phase. The equipment has a theme of gardening and transforms typical fitness equipment into a set of gardening tools, such as a kettlebell watering can. The set includes an interactive mat for various games for the user to participate in, such as stepping on weeds as they grow into the garden.





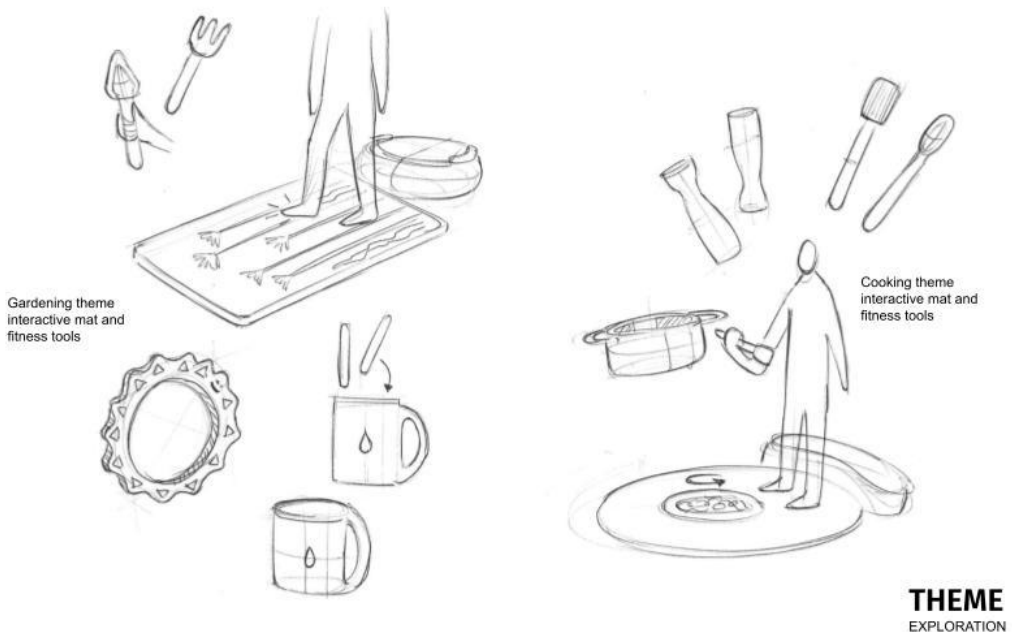
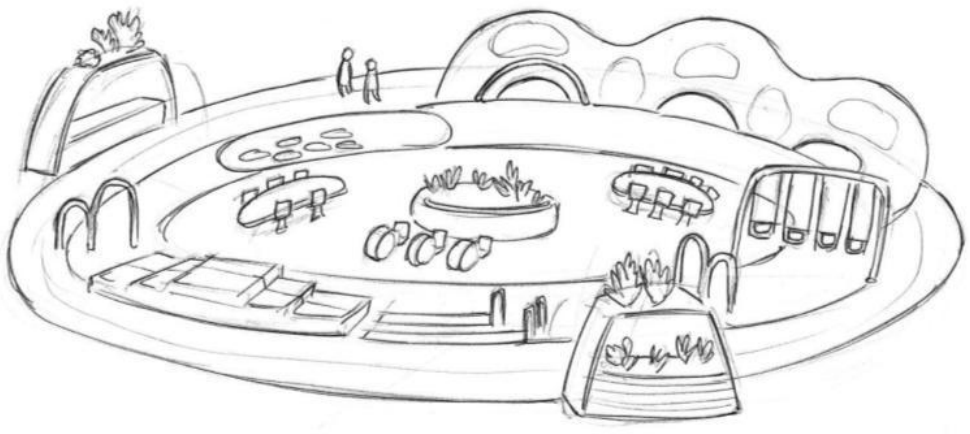


Figure 20: Concept 1 - Gardening Themed Workout Equipment

4.2.3 Concept Three

The third concept is an interactive indoor track that has two lanes: one that is an unobstructed walkway and the other which has obstacles that encourage different types of physical activities. Seniors like to walk so this concept combines their routine of walking and adds additional fitness exercises. The space is indoors so it can be used in the winter time and provides seniors with a space they can congregate.



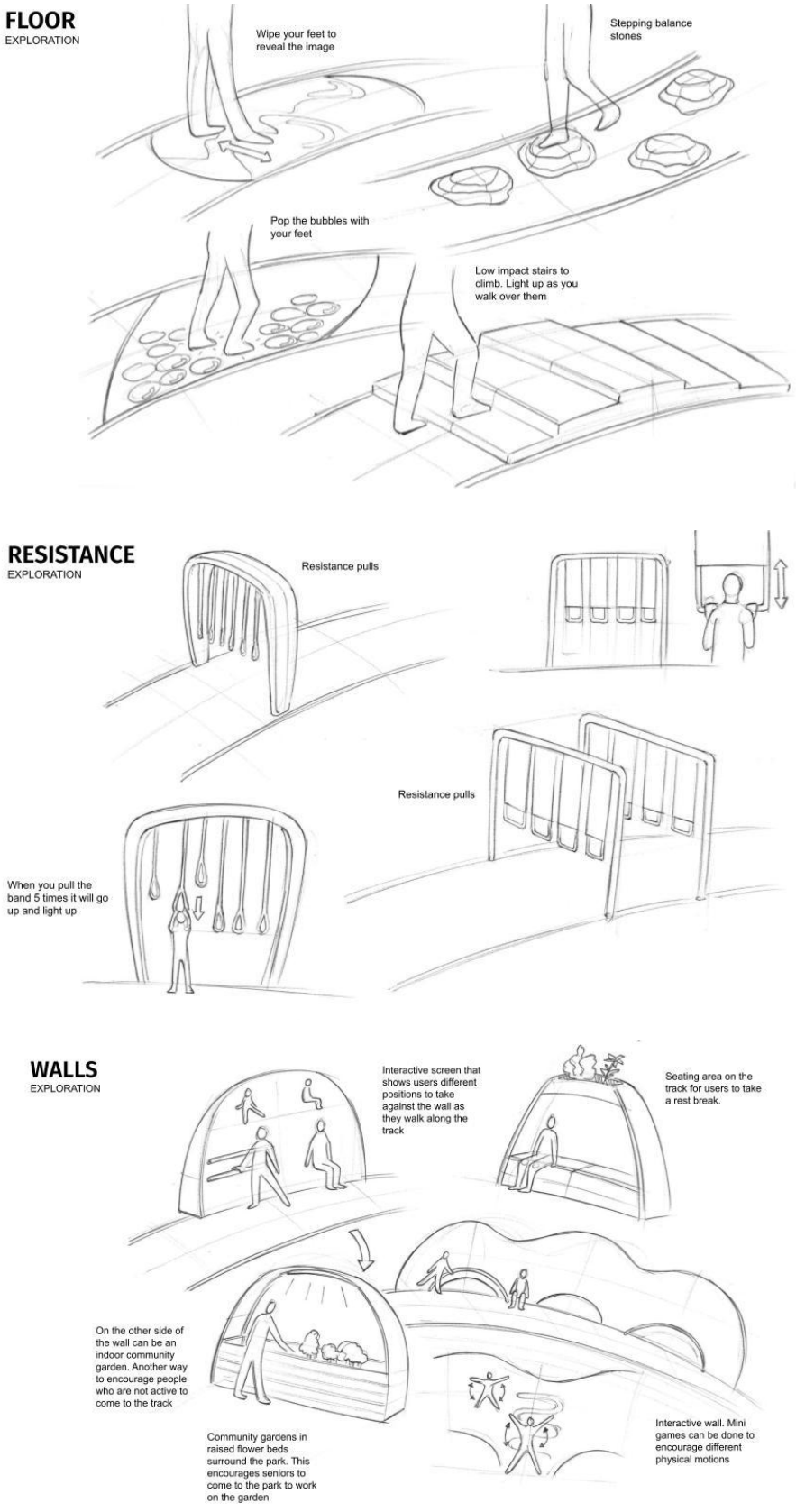


Figure 21: Concept 2 - Indoor Track

4.3 Concept Strategy

From this stage, concept three and a combined solution of one and two were chosen to develop further. At this point in development two schematics were created to begin to understand some preliminary dimensions of each of the two design directions. The schematic in *4.3.1 Concept Direction & Product Schematic One* is the original schematic created for this design direction. The schematic in 3.3.1 is an updated version of this schematic. The schematic in *4.3.2 Concept Direction & Product Schematic Two* was developed based on the indoor track design direction.

4.3.1 Concept Direction & Product Schematic One

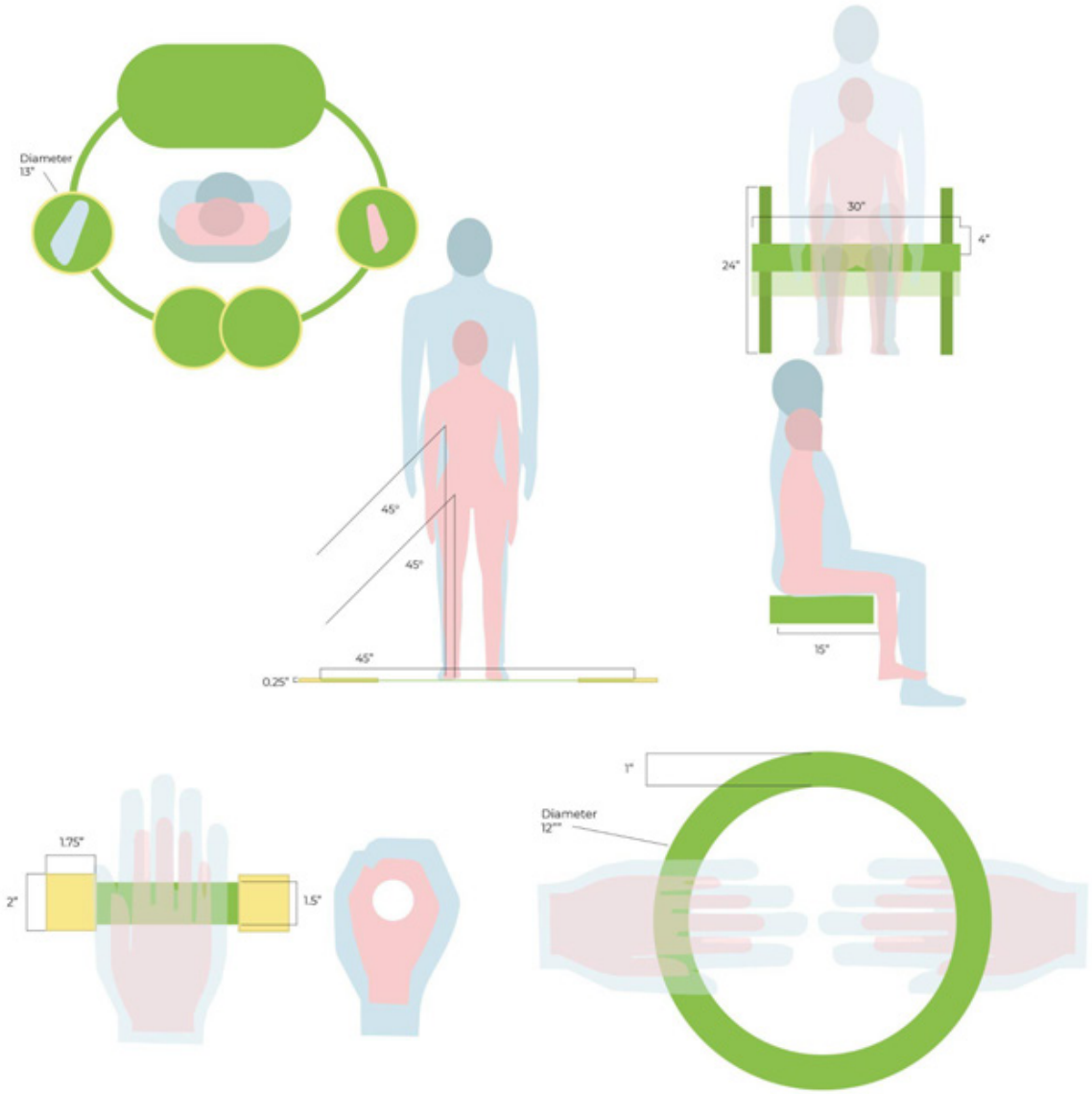


Figure 22: Concept Direction & Product Schematic One

4.3.2 Concept Direction & Product Schematic Two

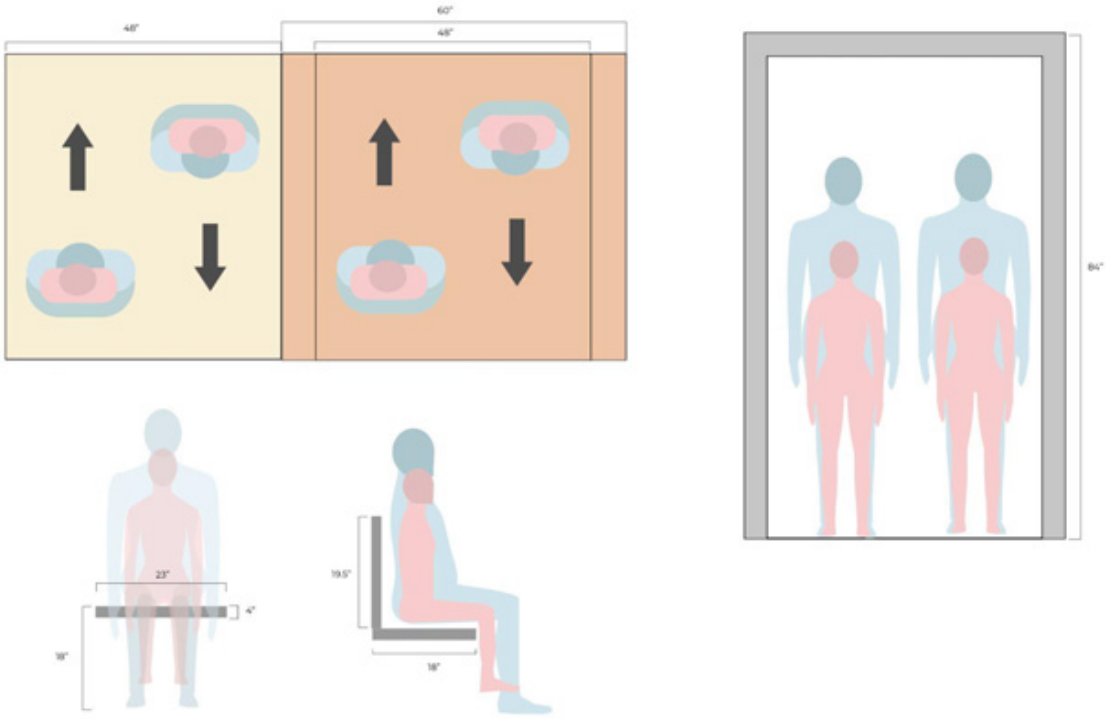


Figure 23: Concept Direction & Product Schematic Two

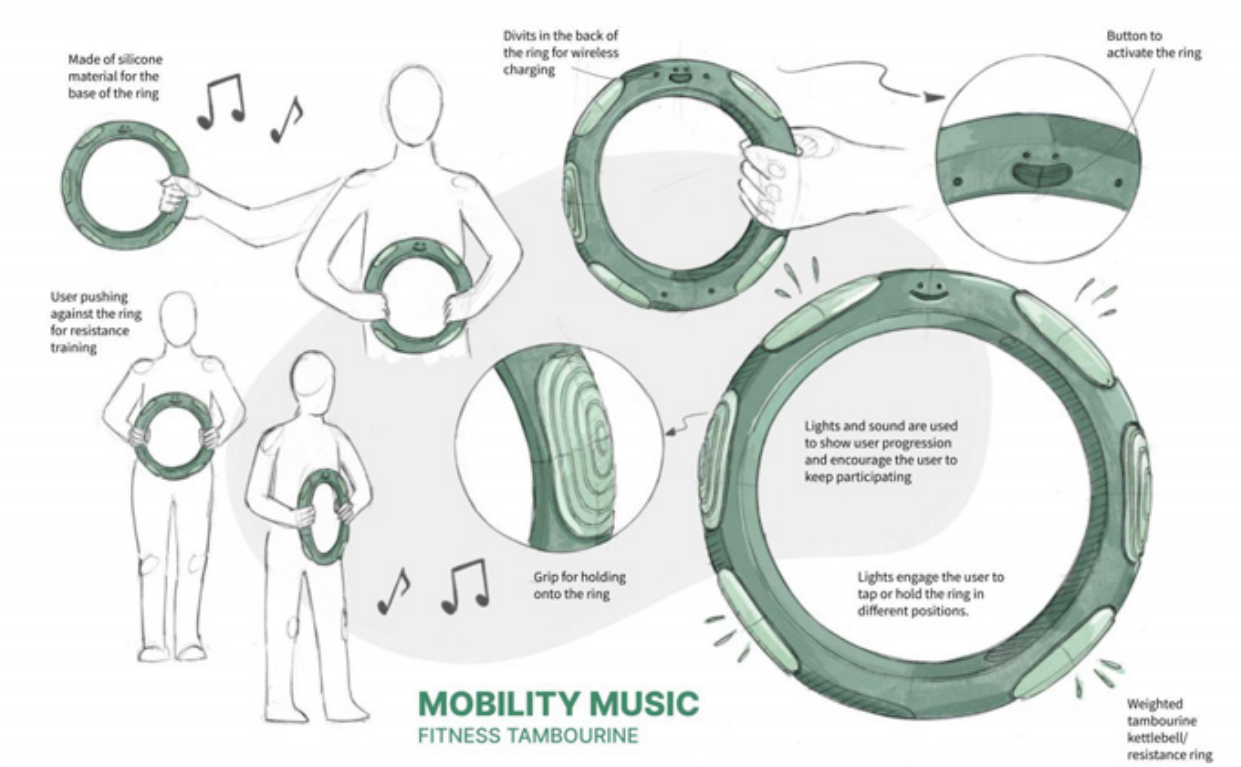
4.4 Concept Refinement & Validation

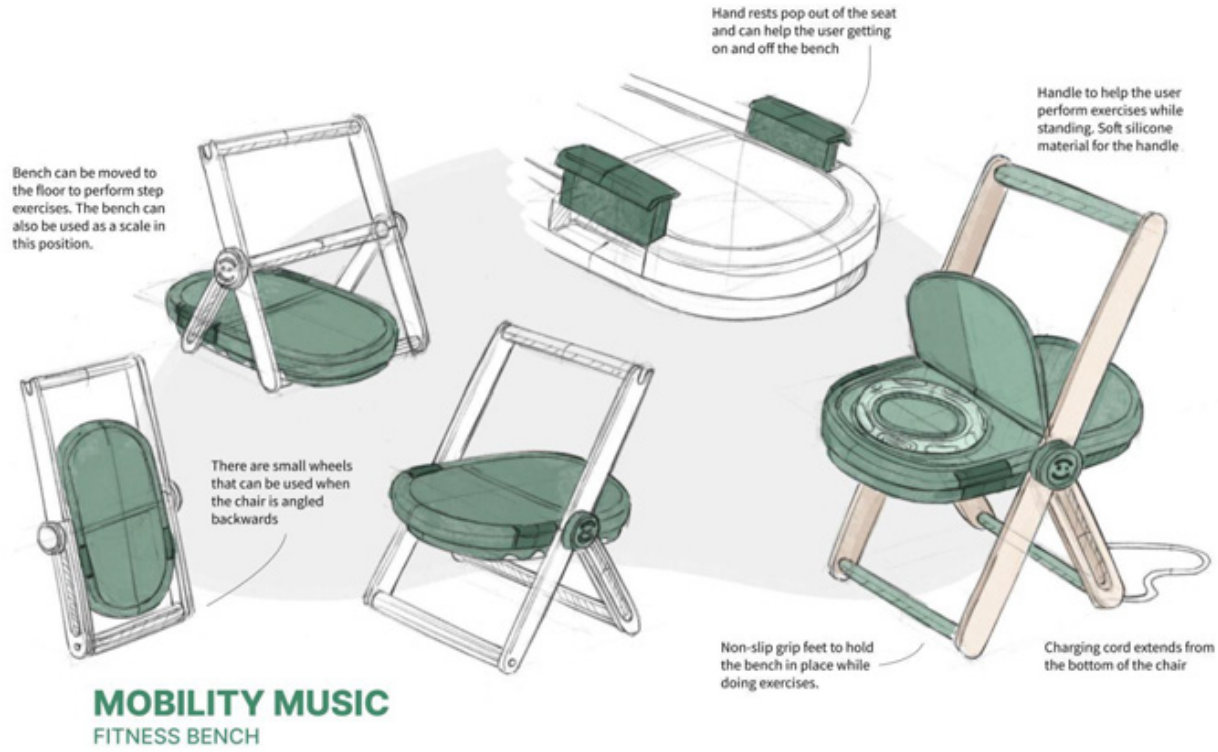
The selected design direction uses the theme of musical instruments from concept one, but integrated a more holistic solution from concept 2. The primary direction that was selected to move forward with was Mobility Music.

4.4.1 & 4.4.2 Design Refinement & Detail Development

The refined concept utilizes a bench seat that is the hub for all of the smart fitness equipment. The bench allows seniors to participate in exercise based on their abilities and gradually become more comfortable exercising at their own pace. The bench allows users to sit, stand with assistance, and take steps with or without assistance. In this iteration, the bench seat height is adjustable to provide proper ergonomic dimensions for exercising, but also allows seniors to adjust the seat height to what they are comfortable with. For instance, a senior may prefer the seat height higher to get on or off the bench until they have built up strength in their legs. There are handles on the seat to allow seniors to use their arms to help them get up from the seat. Two handheld equipment devices are provided and charged within the seat of the bench. The first is a “tambourine” fitness ring which weighs 2 pounds and is flexible to provide resistance and be used for resistance exercises. The

second is a “maraca” dumbbell which can have its heaviness changed by interchanging the center weight. The weight can also be removed so the dumbbells can be held through the center for seniors with weaker grips. Finally, an interactive “drum set” mat is provided to encourage leg movements.





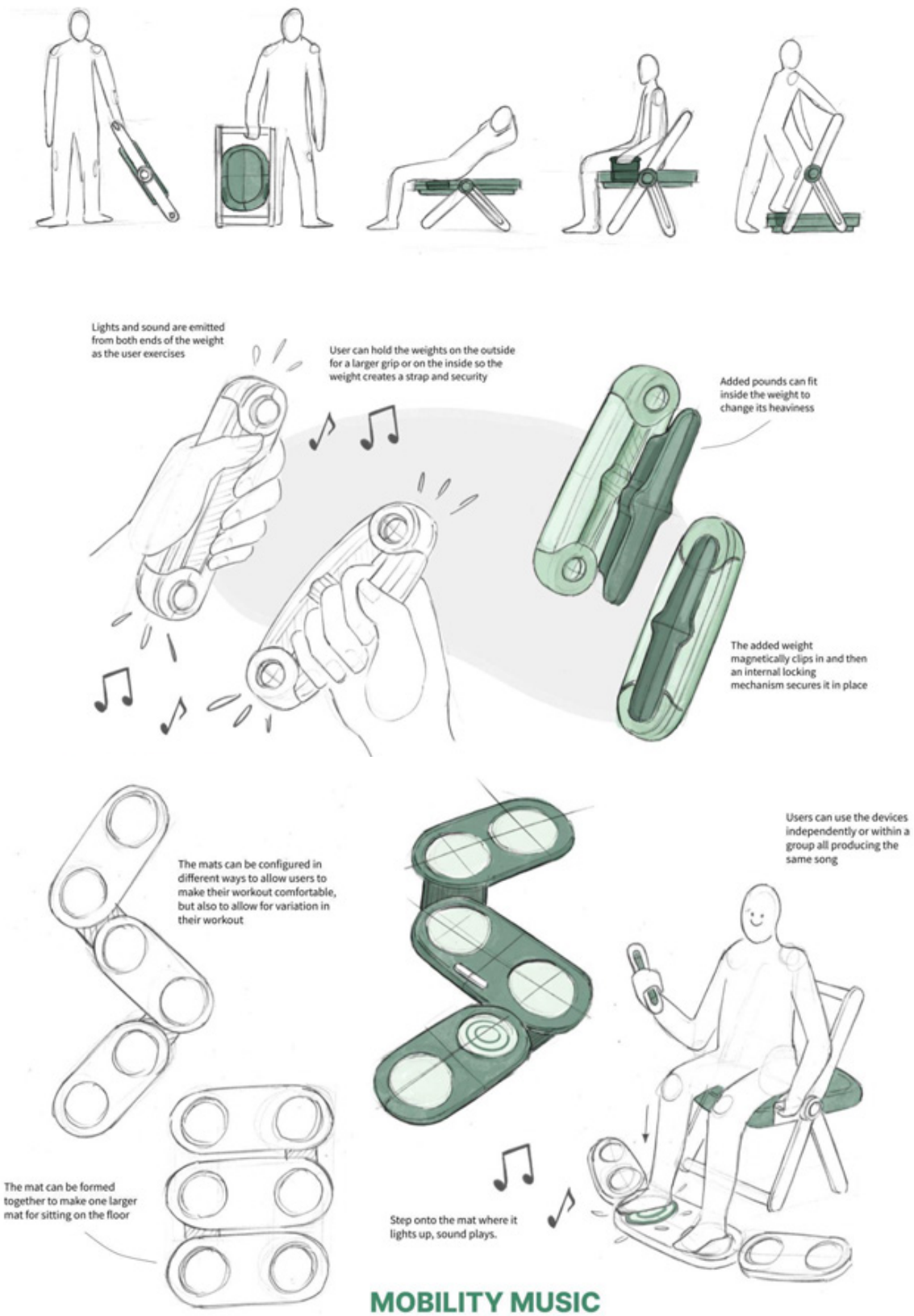
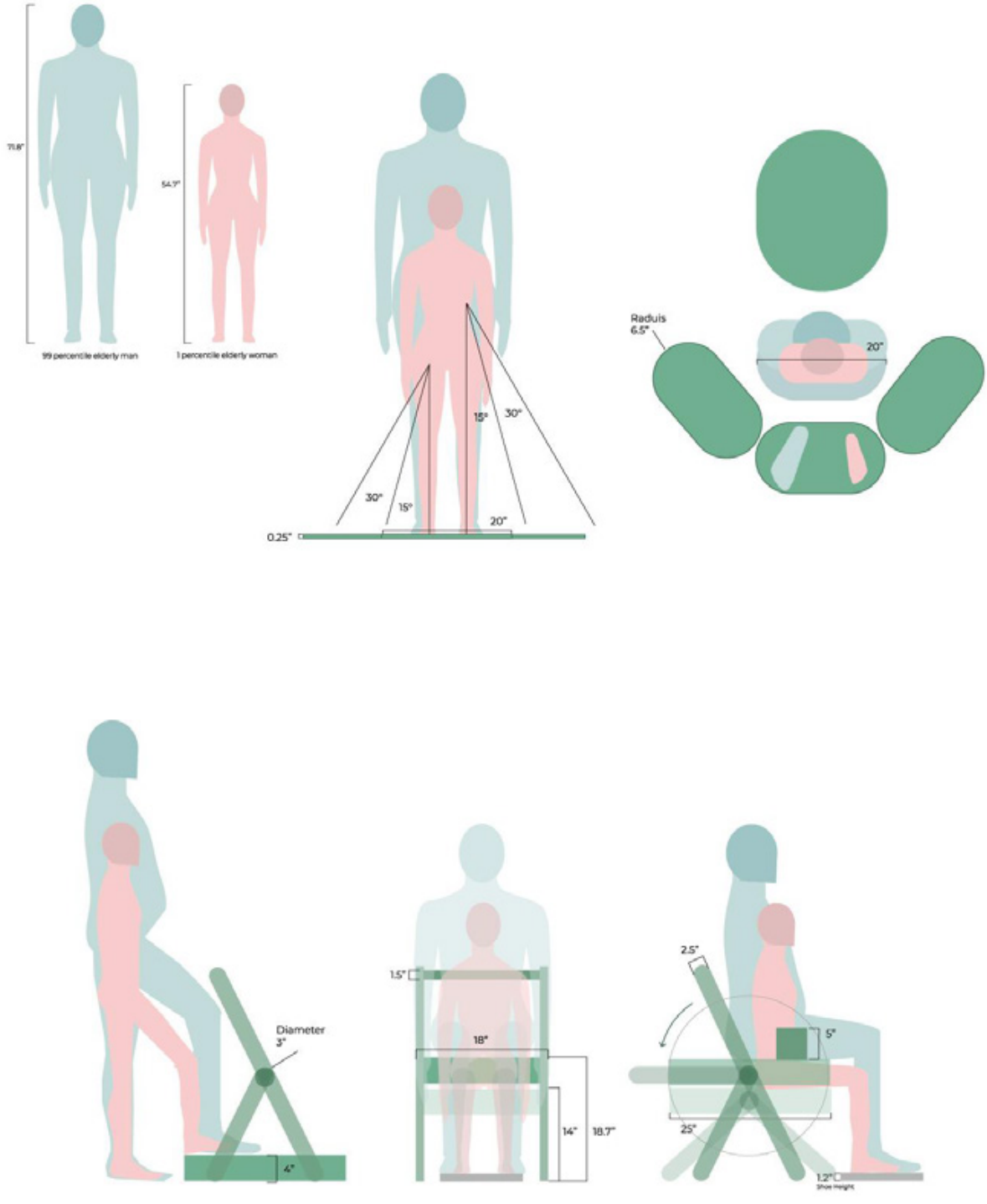


Figure 24: Design Refinement & Detail Development

4.4.3 Refined Product Schematic & Key Ergonomic



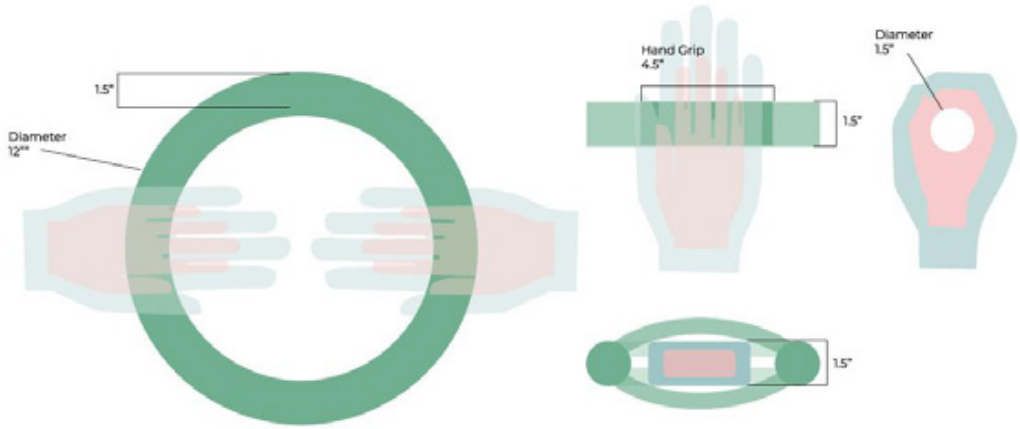


Figure 25: Refined Product Schematic & Key Ergonomic

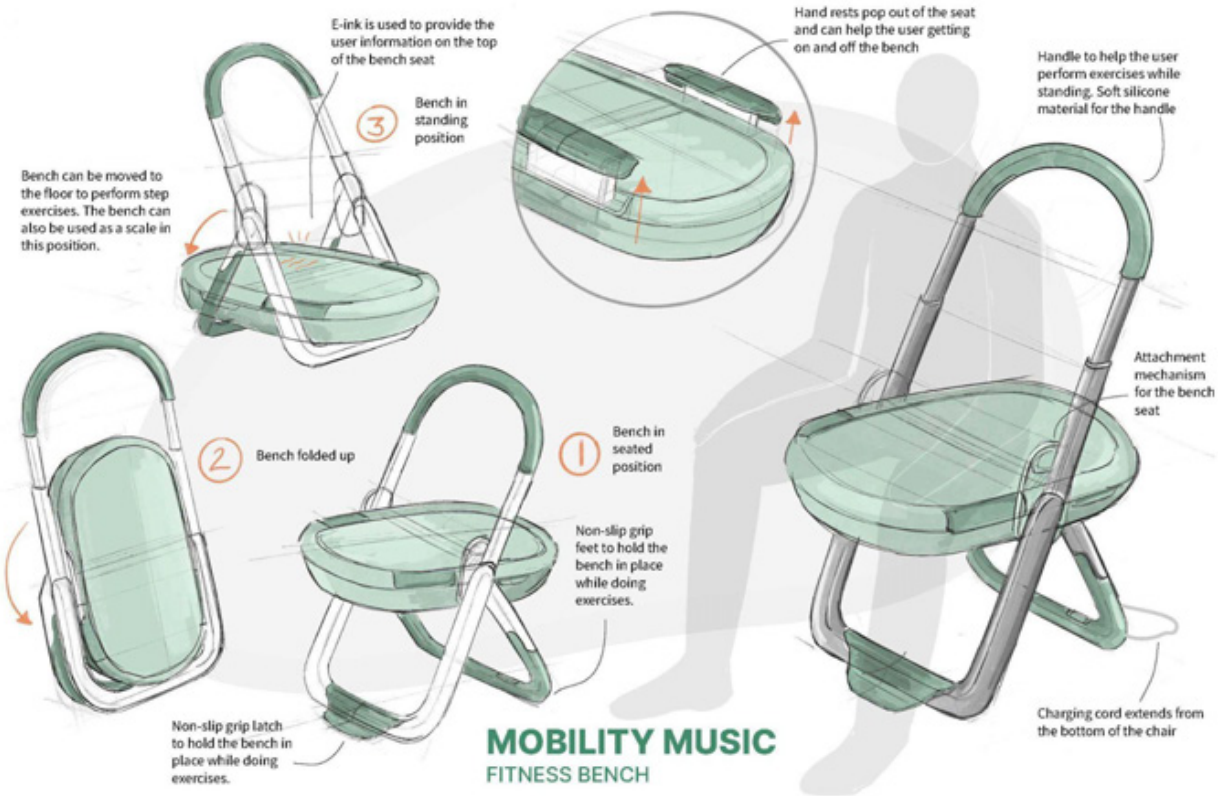
4.5 Concept Realization

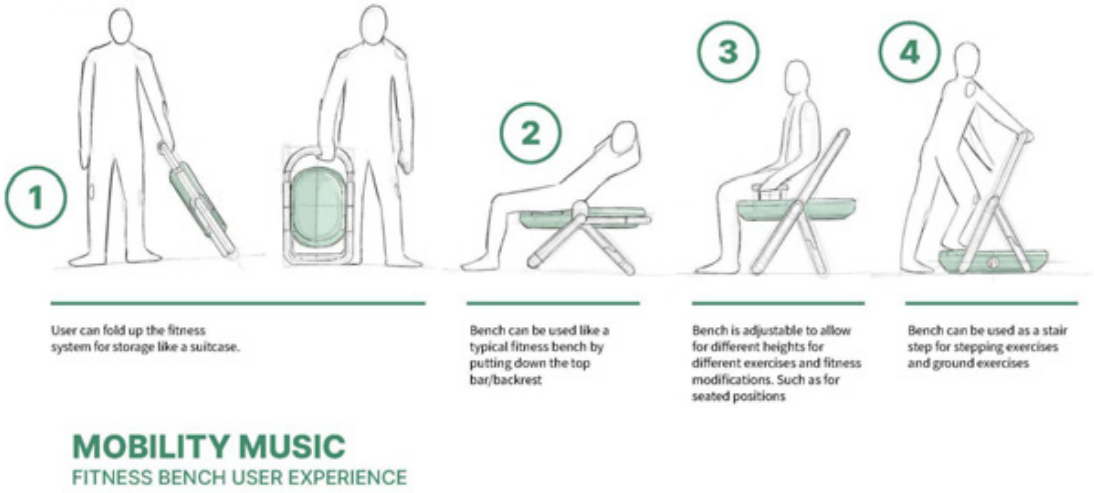
This section will detail the design finalization of the product, showing the final sketches before moving into CAD software and the physical study models that helped inform the final design.

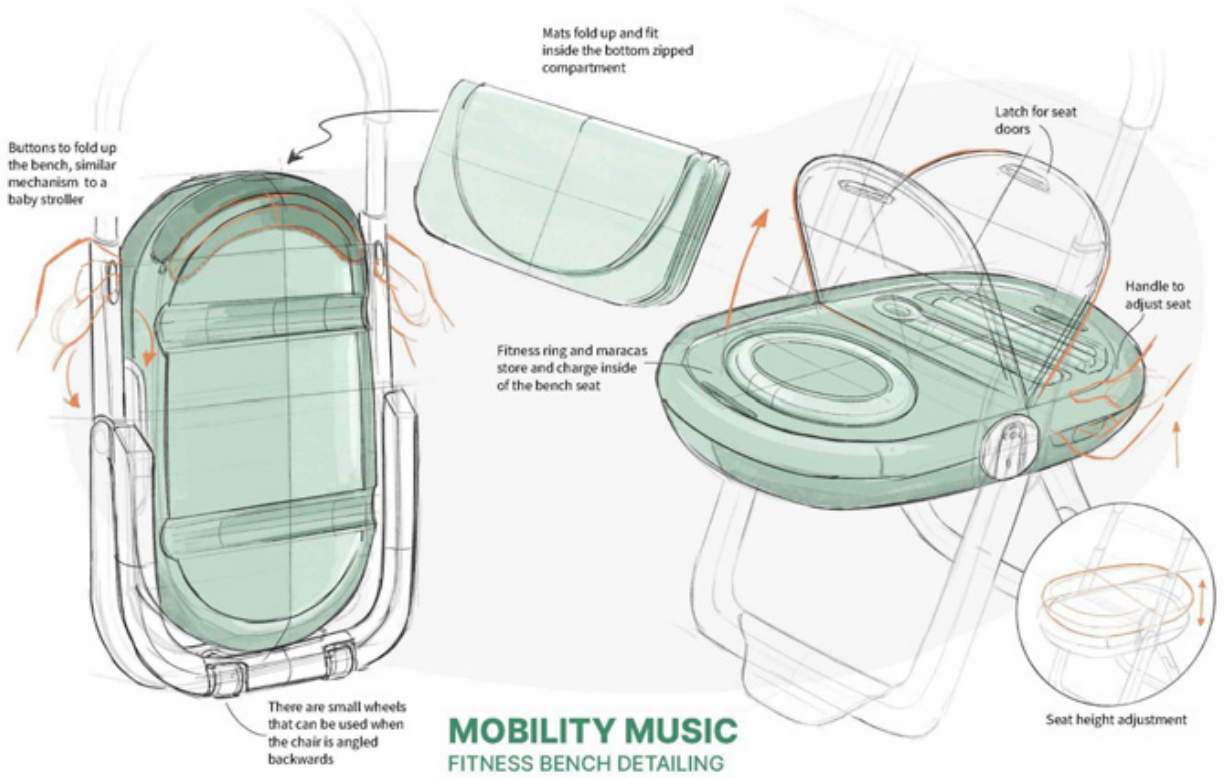
4.5.1 Design Finalization

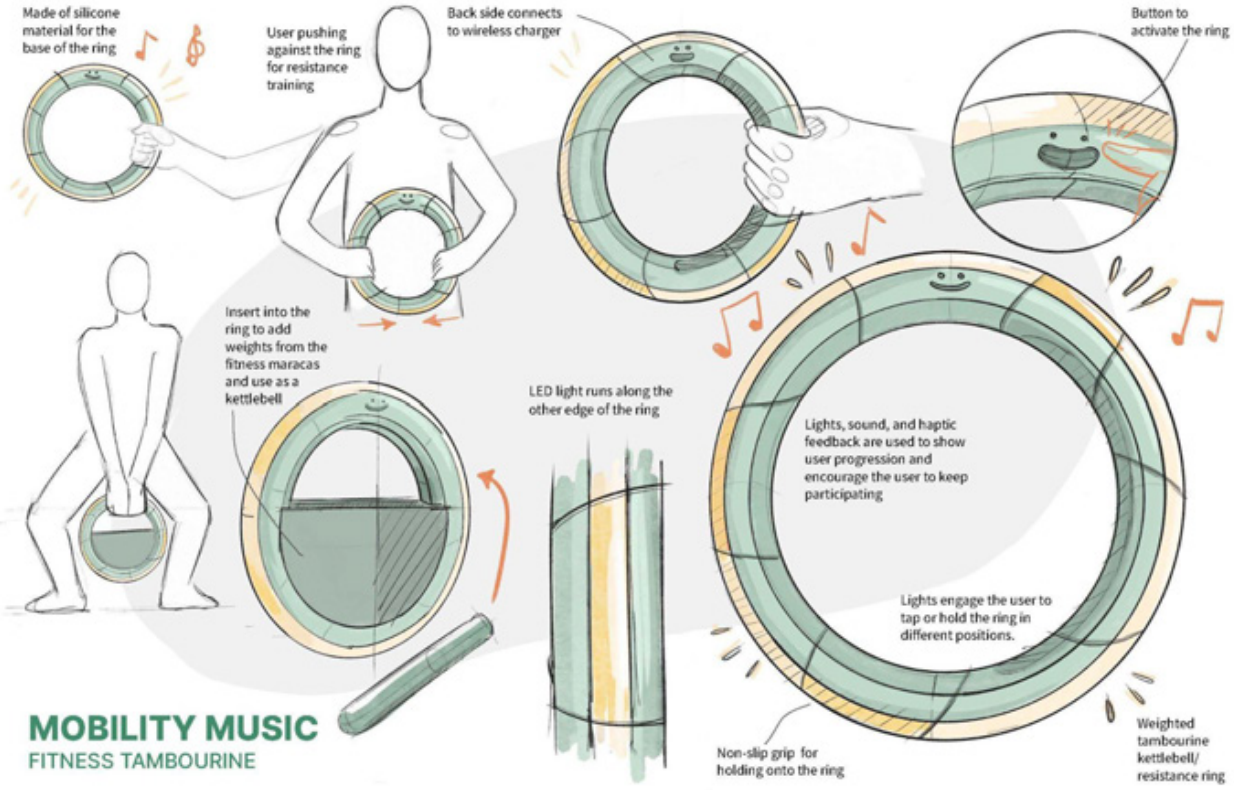
The design finalization sketches depict all of the functions and features of each product in the family of fitness equipment for seniors. In the final concept, there are four included pieces of equipment: rhythm bench, fitness tambourine or ring, drum set mat, and dumbbell maracas. The concept has been refined from the design refinement stage, found in section 4.4.1. The fitness tambourine has been simplified to be a smooth ring shape, as it is more comfortable for the user to handle. The lights wrap around the edge of the ring providing more flexibility for feedback to the user. The dumbbell maracas form has been reimagined, while still maintaining the same functionality as the previous iteration. The form was redesigned as the previous version was less functional, but had a more utilitarian appearance. The head of the dumbbell stores the electronics and lights, while the bottom is modular and can be interchanged for different weight sizes during workouts. The dumbbells can also be combined at the circular center using neodymium magnet connection to create a resistance stick. The drum mat was simplified to be a regular sized mat that instead of having multiple parts display the interactions on the mat in 3D forms using robotic fabric. There would be three included mats that can be used together or separated to add more players. Finally the workout bench details

were refined so the bench is primarily made of plastic with an aluminum frame. The details were inspired by baby stroller designs which use a combination of these materials to look both friendly, approachable, but also sleek. The bench functions similar to the previous iteration, folding and supporting the user while sitting and standing. In addition to storing all of the equipment into the base of the bench. Finally there is a revised schematic that would be used to begin CAD development of the model.






Mats fold up and fit inside the bottom zipped compartment
Buttons to fold up the bench, similar mechanism to a baby stroller
Latch for seat doors
Handle to adjust seat
Fitness ring and maracas store and charge inside of the bench seat
There are small wheels that can be used when the chair is angled backwards
Seat height adjustment
MOBILITY MUSIC
FITNESS BENCH DETAILING


Made of silicone material for the base of the ring
User pushing against the ring for resistance training
Back side connects to wireless charger
Button to activate the ring
Insert into the ring to add weights from the fitness maracas and use as a kettlebell
LED light runs along the other edge of the ring
Lights, sound, and haptic feedback are used to show user progression and encourage the user to keep participating
Lights engage the user to tap or hold the ring in different positions.
Non-slip grip for holding onto the ring
Weighted tambourine kettlebell/ resistance ring
MOBILITY MUSIC
FITNESS TAMBOURINE

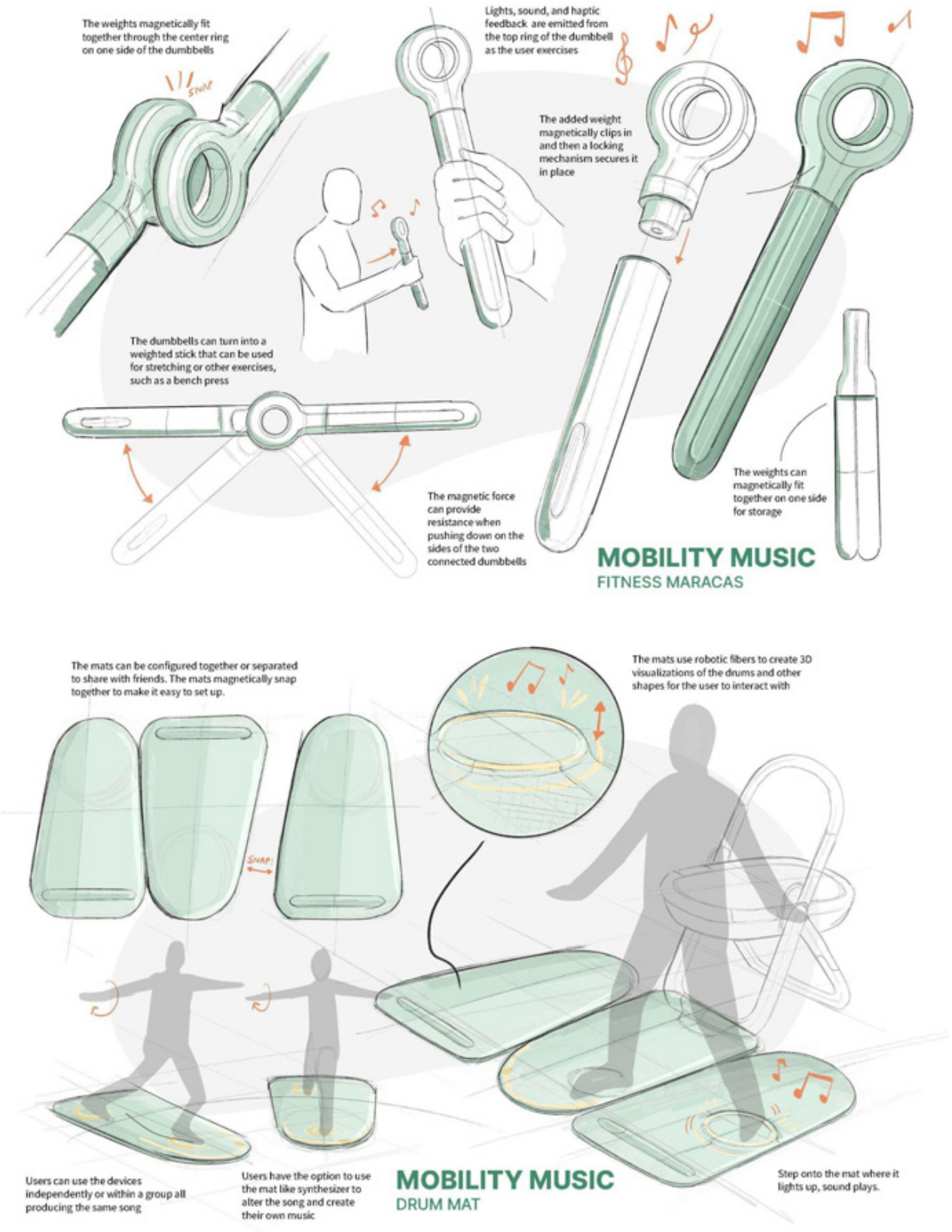
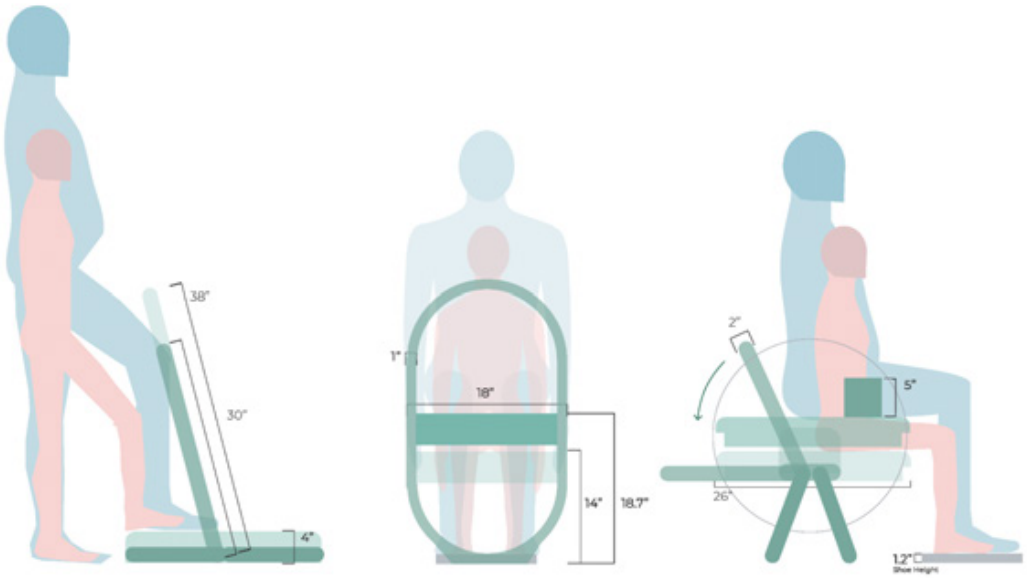
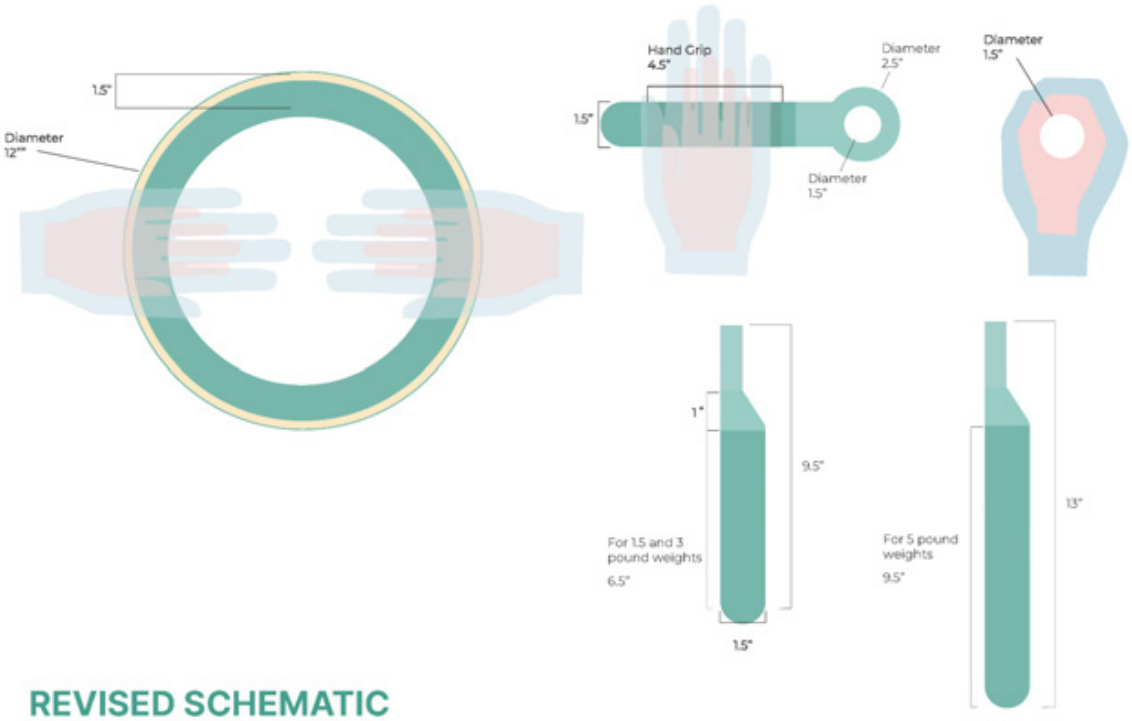


Figure 26: Design Finalization Sketches



REVISED SCHEMATIC



REVISED SCHEMATIC

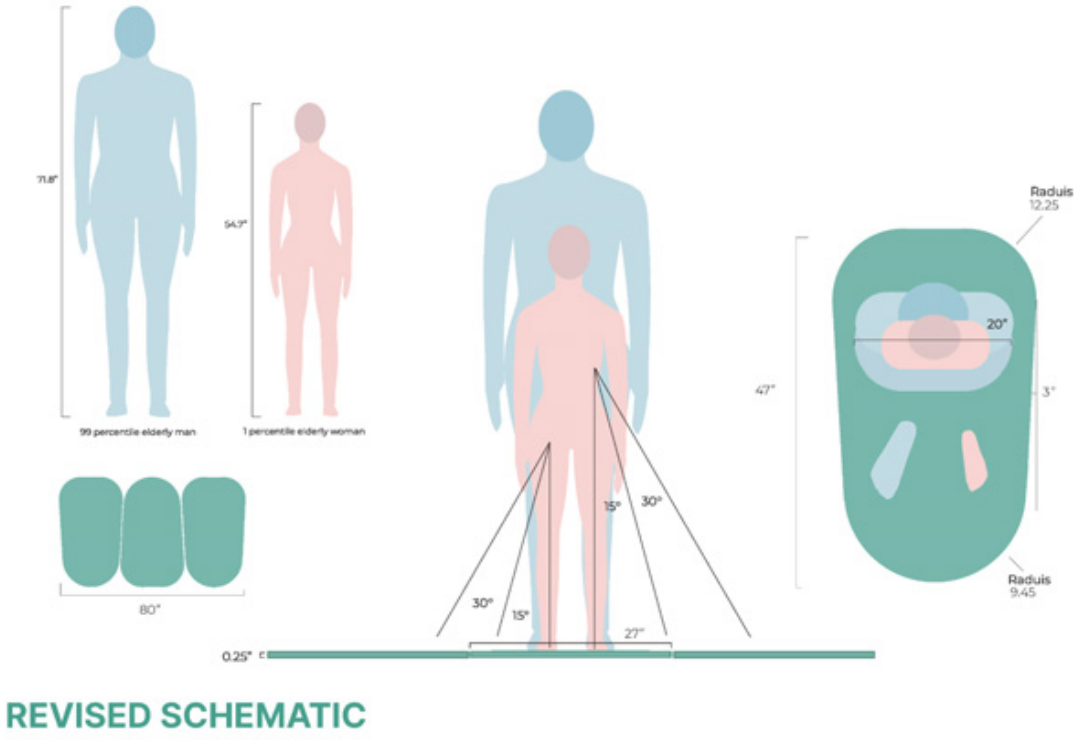


Figure 27: Revised Schematic Based on Design Finalization

4.5.2 Physical Study Models

To get a better understanding of the physical size of the product a 1:1 model was created. This 1:1 scale model of the entire product family helped to inform the sizing of the design and allowed for minor adjustments to be made in the CAD for the dumbbells, tambourine, and the mat. The major adjustments that needed to be made were to the workout bench. From this study it was discovered that the proportions of the bench seat base to the legs and handle were off. The bench was about an inch larger than was required. The legs were too short to meet the ergonomic seat height but to make the legs longer would not allow them to fold into the suitcase position. The handle did not fold into an appropriate length and dangled too far out on the side of the bench. The round legs were not aesthetically pleasing and did not provide the stability required for the bench to be functional for seniors. Finally, the axis of the legs was in the center of the bench which made it wobble and was less stable for sitting on. The other equipment fit inside of the bench nicely, except there was no additional room for the extra two workout mats that were part of the design finalization. These issues would be addressed and resolved in the final design resolution.

After this phase, additional ⅛ scale physical models were created to help brainstorm the possibilities for the movement and folding mechanisms of the legs.

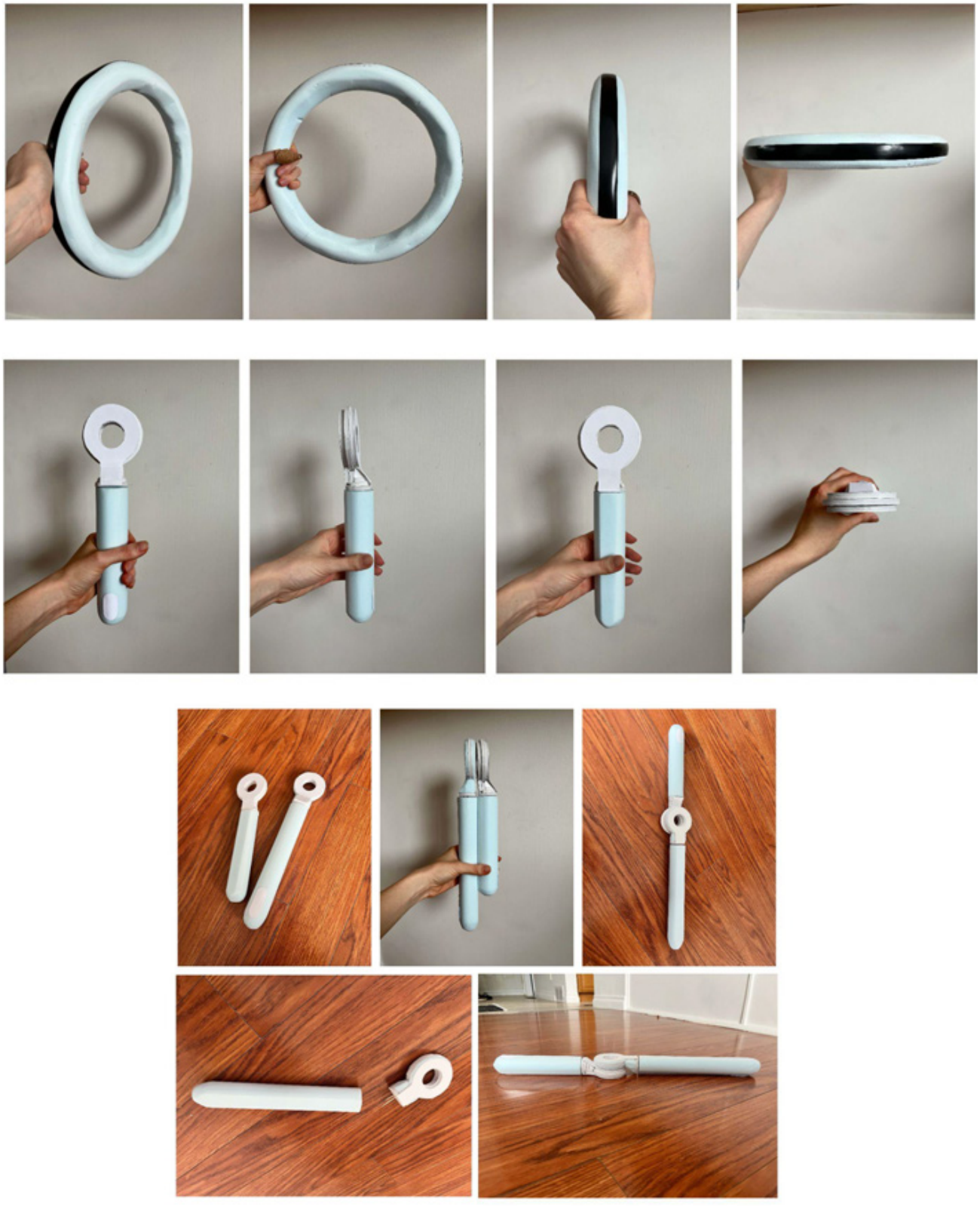


Figure 28: 1:1 Sketch Model - Dumbbells and Ring

Figure 29: 1:1 Sketch Model - Bench & Mat

4.6 Design Resolution

The design detail resolution involved identifying placement of small details such as buttons and handles for electronics and modular components. The goal was to place these details in locations that were ergonomic and intuitive to the user. In addition, refining the form and creating consistency across the 4 devices to ensure they looked like a product family. This includes consistent use of chamfers and radius on the products, as well as the wave design detail that is present on each product in the family. Finally, there was a lot of thought put into how the internal of the electronic components would work that influenced the placement on the devices.

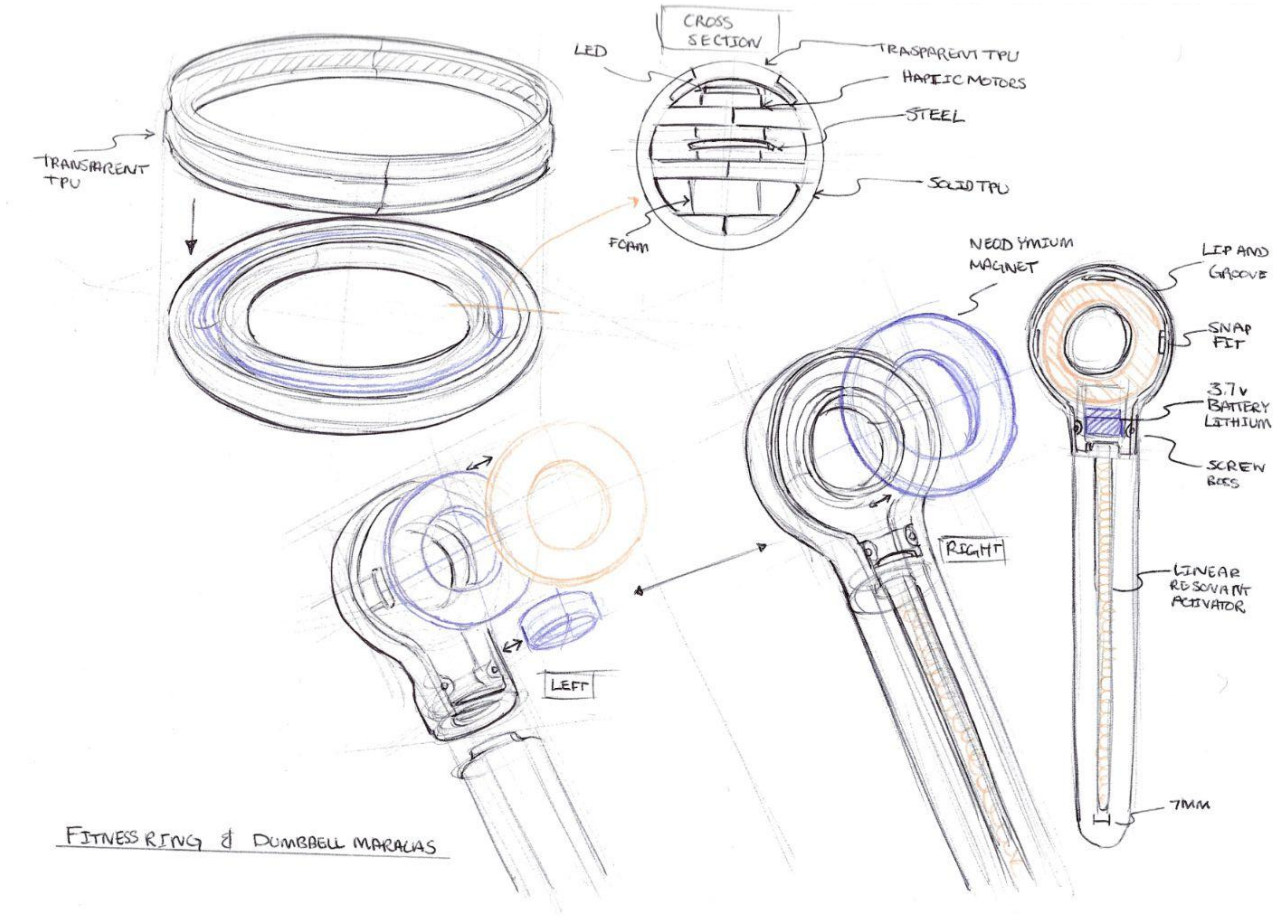
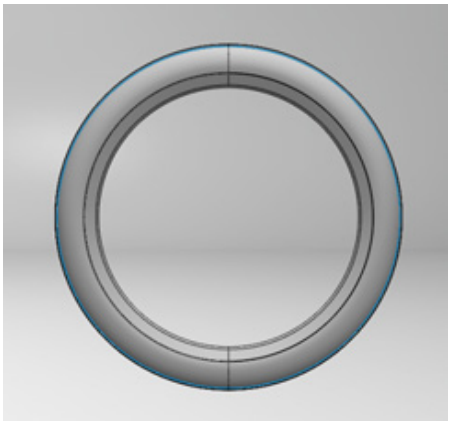
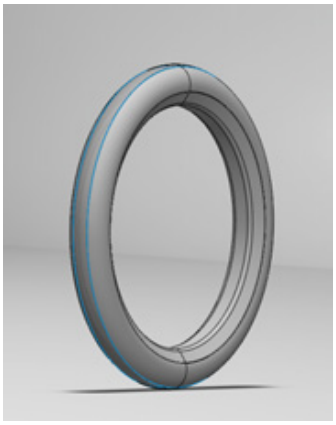
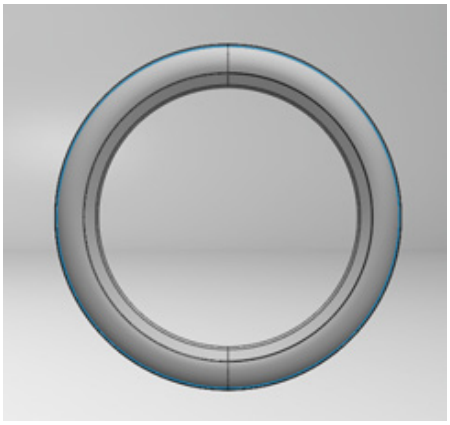
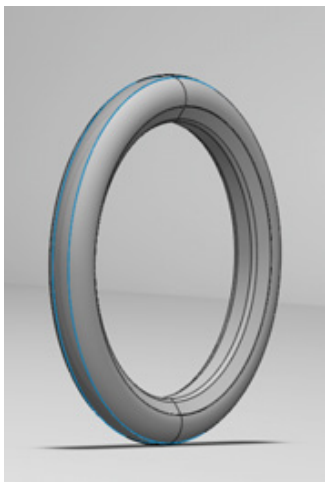
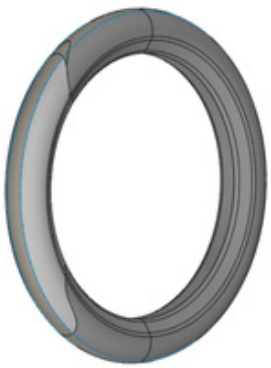
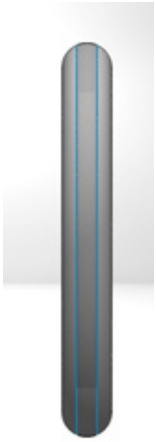
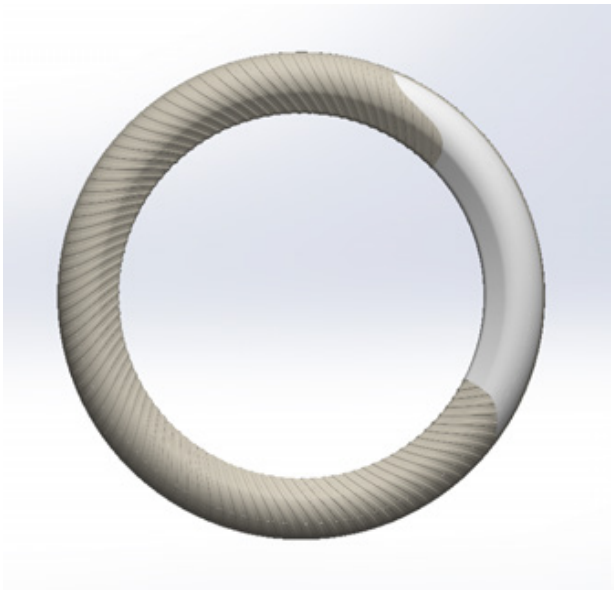


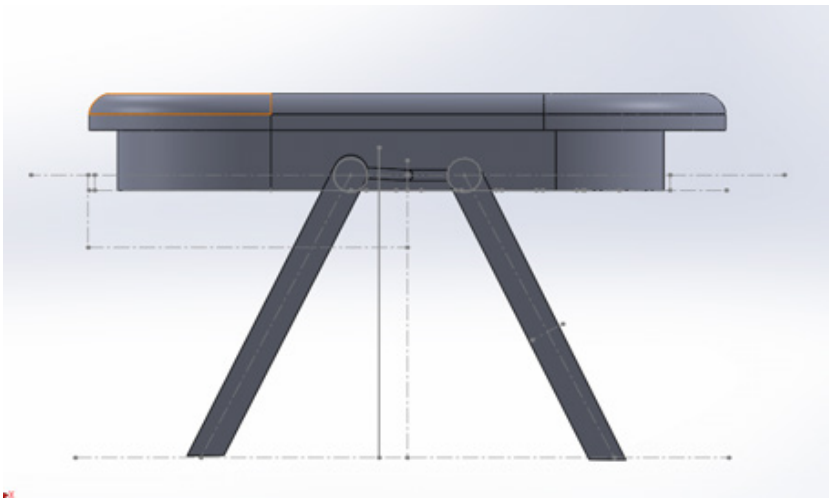
Figure 30: 1:1 Sketch of Internal Components - Dumbbells & Ring

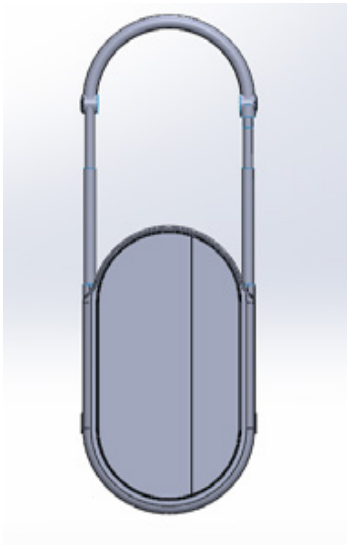
4.7 CAD Development

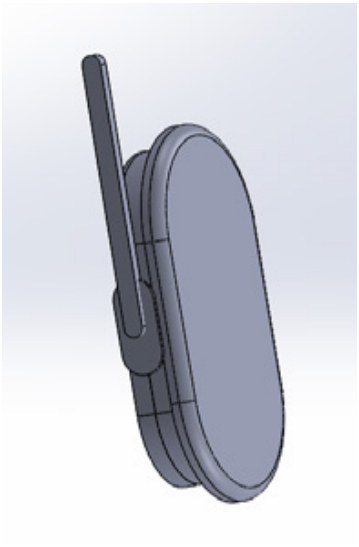
The CAD development process primarily took place over 3 weeks and Solidworks was chosen as the software to model the design. The process began with quick visualization CADs to understand the proportions and feasibility of the products. For this project surfacing modeling was primarily used since it offered more flexibility when detailing the design and allowed for more complex curvatures. These CADs were particularly important for the design development of the bench since it had many moving parts and the dimensions and functionality influenced the final look of the product. After doing the initial CAD of the bench it was determined that the way the legs and the top handle were folding into the suitcase was not functional or resolved. In addition to this, the centered handle made the bench less functional for seated positions and for the step platform. These issues were resolved in the final design where the handle and the back leg were moved to the edge of the seat. The folding suitcase mechanism was challenging to problem-solve but was rewarding to have figured out and resolved the design. Shortcomings with the CAD were the lack of time to detail the interior electronics and mechanisms of the handheld devices and of the bench.

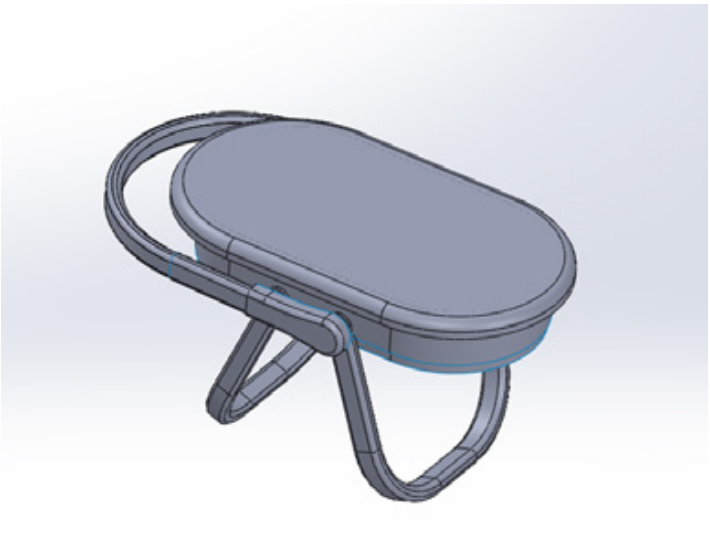







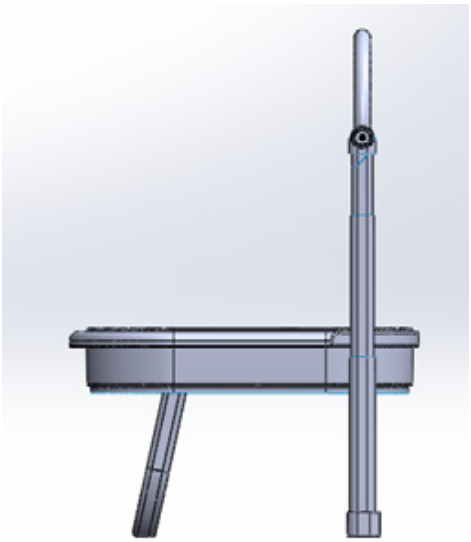










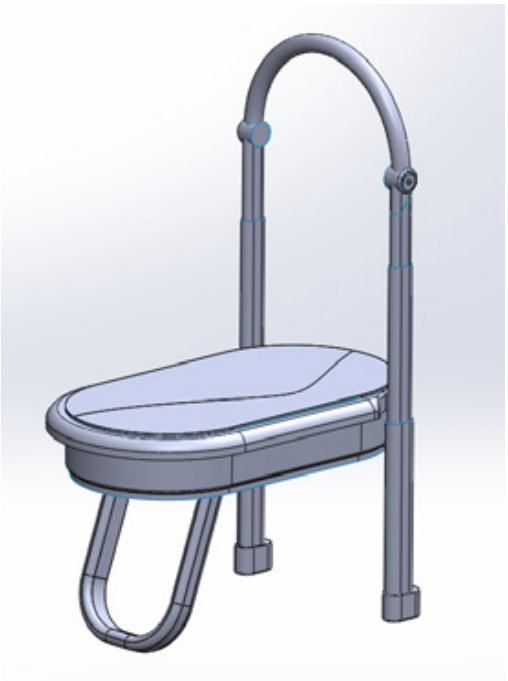


Figure 31: CAD Development

4.8 Physical Model Fabrication

After completing the CAD modeling the design was then set-up to be 3D printed. The model print was outsourced to a local 3D printing company, Agile Manufacturing. The model was printed at ¼ scale in high quality resin, which retained the small details of the design and required minimal sanding. The model was then primed in gray for dark parts and white for lighter parts. The dark green, translucent and aluminum parts were spray painted. The base of the bench was hand painted with acrylics since the coloring of the bench could not be found in commercial spray paints. The acrylic paint was coated with a matte clear coat to protect it from chipping and damage. The mat was created by painting a foam mat used for protecting shelving.

Figure 32: Physical Model Fabrication

final design 05

5.1 Design Summary

The rate of inactive or sedentary lifestyles is increasing among Canadian seniors, which negatively impacts their risk of health complications and quality of life. Seniors that are inactive are more at risk for a variety of health conditions, including obesity, heart disease, hip fractures from falls, and premature mortality. These health risks also have a financial impact on the Canadian government, with injuries from falls alone costing $2 billion yearly. As the research has shown, staying active and exercising can help maintain normal functional mobility, such as getting in and out of a chair or going up and down stairs. Exercise is understood to be a long-term preventative measure against illness and injury. As we age we continue to lose muscle mass which makes it important to maintain strength for functional mobility. Without regular exercise, after the age of 30, muscle mass can reduce by roughly 3-5% every decade (Webmd, 2022). There are currently very few fitness products on the market that are designed for this target demographic and none that were found address the issue of muscle mass loss for seniors.

Rhythm is an interactive and gamified fitness equipment set designed for seniors that uses music, lights and haptic feedback to enhance their fitness experience. There are four components to the set that aid seniors in completing basic exercises to maintain their functional mobility: dumbbell maracas, fitness tambourine ring, workout bench, and a drum mat. The solution also includes a phone and tablet application that provides workout challenges and games for seniors to work through (see Appendix C). The app shows seniors proper positioning for exercises and provides feedback if they are completing exercises correctly or not. Users work through a variety of micro workouts and earn points and achievements as they complete tasks. Rhythm can be played individually, but is more fun when working out together with friends. Each equipment piece can add an additional player and provides unique tasks for each equipment type. The fitness equipment design is inspired by instruments. This makes playing the workouts together similar to playing in a band. The bench is designed to support seniors while sitting or standing. The vertical handle can be extended for a standing position or retracted to be a support handle when moving from sitting to standing. The top of the handle can also be folded for different standing positions or be folded down so it is out of the way. The bench stores all of the fitness equipment and can be folded into a suitcase for easy storage and transport. The handheld devices, the tambourine ring and dumbbell maracas, are used for resistance and strength training. These handheld devices include lights, haptic feedback, and speakers to provide feedback to users. The equipment makes music as they complete their workout challenges. Finally, the drum mat uses robotic fabric, lights, and speakers to give feedback to users. Areas on the mat will become raised which will show where they need to step to or position their body for exercises. The 3D effect provides an additional layer of feedback and makes the experience more immersive.

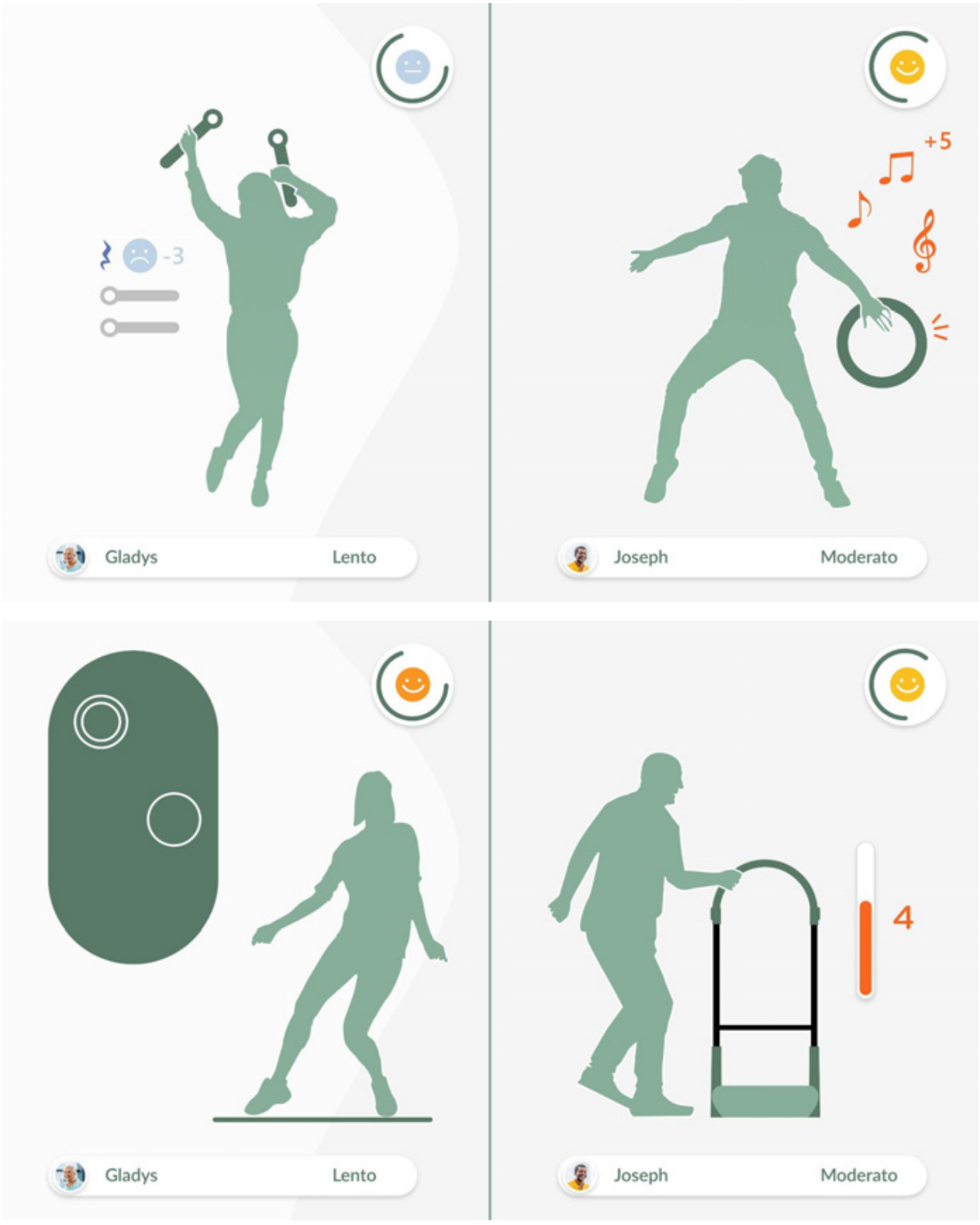


Figure 33: Digital Tablet or Phone App that is cast to television screens

5.2 Design Criteria Met

5.2.1 Full Bodied Interaction Design

The design project is a full bodied interaction design, therefore the design includes multiple human body touchpoints that require ergonomic considerations. The major human body touchpoints in the design are on the workout bench. The bench has 4 ergonomic human body touchpoints: the seat of the bench for sitting (torso and legs), the handle when moving from sitting to standing (arms and hands), the bench when it is in the step platform position (feet and legs), and finally the bench suitcase position (hands, arms). The handheld devices have hand touchpoints and the drum mat has feet touchpoints.

5.2.2. Materials, Processes and Technology

In this section the materials, processes, and technology used in the design will be discussed. The four products in the equipment set will be broken down in detail, including: the Rhythm Bench, Dumbbell Maracas, Tambourine Ring and Drum Mat.

Rhythm Bench

The bench seat is primarily made of polypropylene, since this material is very durable, biologically inert, and recyclable. The feet of the bench are also made of polypropylene and the handle is made of TPU foam. The frame of the bench is made from aluminum as it is lightweight for seniors to handle and is infinitely recyclable. The bench contains a battery so it can wirelessly charge the handheld devices when they are stored inside. The bench charges through a port at the back of the base. The bench also has the ability to be used as a scale when the seat of the bench is moved to the floor, in the step platform position (see section 5.3).

Dumbbell Maracas & Tambourine Ring

The housing for the head of the dumbbell is made of polyethylene since this material allows an infrared camera to see through, which is necessary for accurate motion controls. The weight is made of steel and has a TPU cover which is removable for the end of life cycle of the weights. There is a lot of technology inside the dumbbell maracas. There is a linear resonant actuator in the center of the steel weight, which creates the haptic feedback. The head of the dumbbells stores a 3.7 volt battery, lights, speaker, and neodymium magnets that are used for resistance training. There is a mechanism

inside that turns the magnets to allow the magnet to turn on and off, so they are not always magnetized (see section 4.6).

The tambourine ring is made out of TPU for its soft and flexible material properties. The ring is flexible and bends for resistance training. Inside the ring are haptic motors, LED lights, speakers, a USB-C port, and a coiled steel ring which provides resistance.

Drum Mat

The Drum Mat is primarily made of TPE with robotic fibers woven in to allow the mat to create a 3D effect when communicating steps and positioning to the user. There are also embedded lights in the robotic fiber for added information. The mat splits in half and reconnects using magnets. The mat splits into two so another player can be added into the game.

5.2.3 Design Implementation

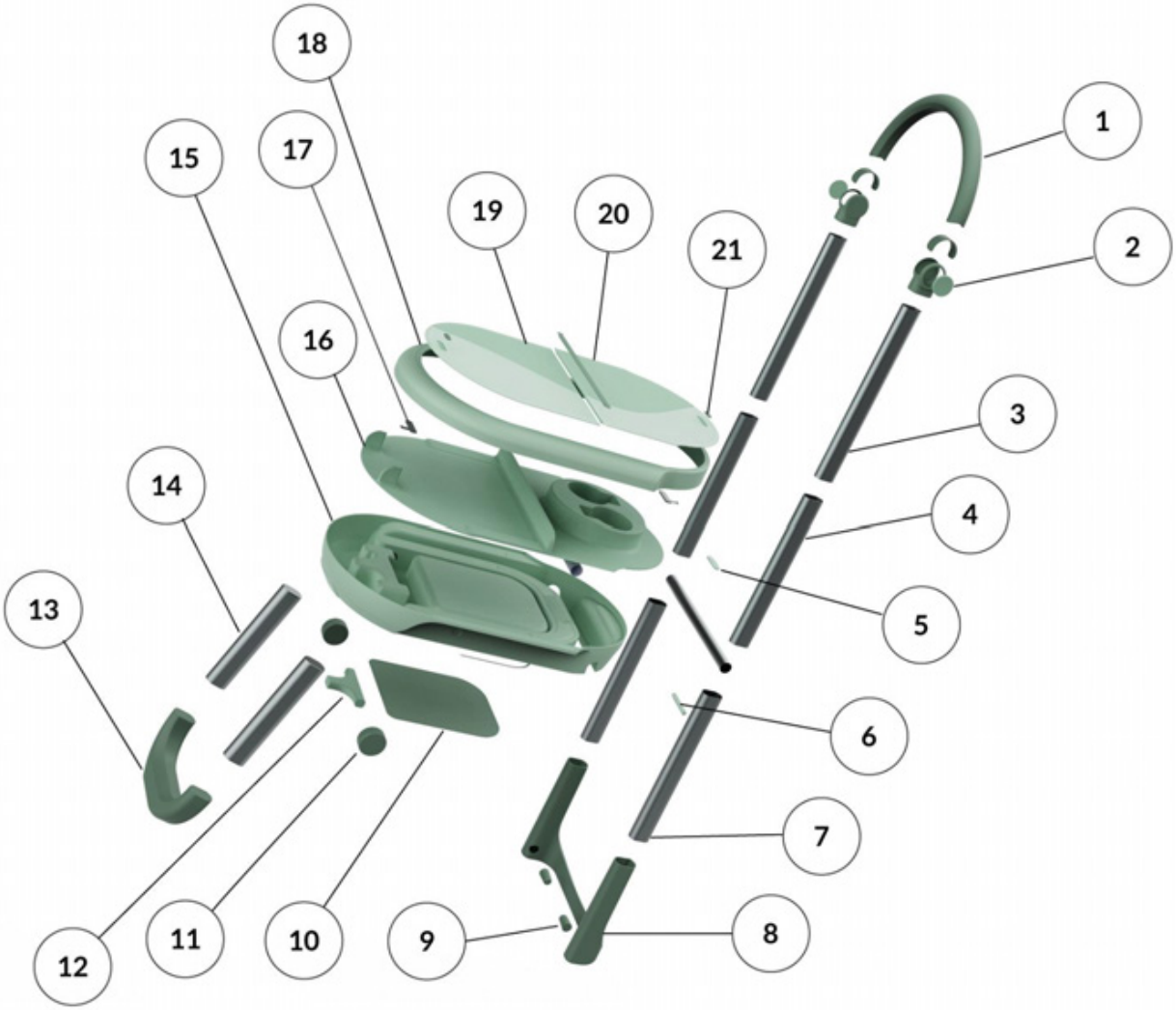


Table 14: Bench BOM

Part #	Description	Quantity	Material	Manufacturing Method
1	Handle Top	1	TPU Foam	Extrusion
2	Handle Mechanism	2	Polypropylene and Steel	Injection Molding
3	Back Leg Top	1	Aluminum	Aluminum Extrusion
4	Back Leg Middle	1	Aluminum	Aluminum Extrusion
5	Bench Seat Release Button	1	Polypropylene	Injection Molding
6	Back Leg Button	1	Polypropylene	Injection Molding
7	Back Leg Bottom	1	Aluminum	Aluminum Extrusion and Welding
8	Back Foot	1	Polypropylene	Injection Molding
9	Back Foot Pins	2	Polypropylene	Injection Molding
10	Mat Pocket	1	Cotton	Woven
11	Wheels	2	Blow Molded	Polyurethane
12	Wheels Axle Housing	1	Polypropylene	Injection Molding
13	Front Foot	1	Polypropylene	Injection Molding
14	Front Legs	2	Aluminum	Aluminum Extrusion
15	Seat Base Bottom	1	Polypropylene	Injection Molding
16	Seat Base Middle	1	Polypropylene	Injection Molding
17	Lid Latch Assembly	2	Steel	Metal Forging
18	Seat Base Top	1	Polypropylene	Injection Molding
19	Seat Front Lid	1	Polypropylene	Injection Molding
20	Seat Back Lid	1	Polypropylene	Injection Molding
21	Seat Lid Release Buttons	2	Polypropylene	Injection Molding

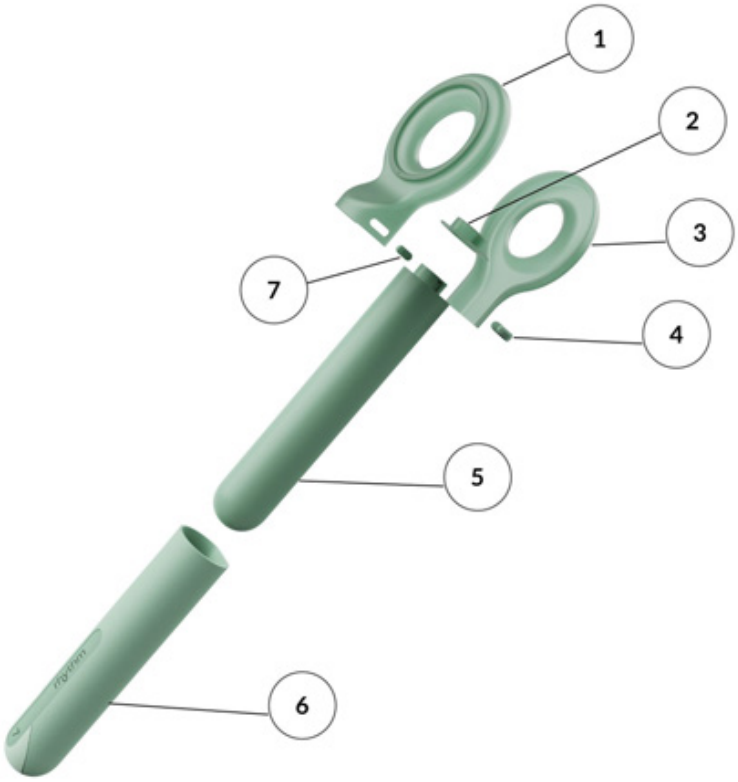


Table 15: Dumbbell BOM

Part #	Description	Quantity	Material	Manufacturing Method
1	Handle Top	1	TPU Foam	Extrusion
2	Handle Mechanism	2	Polypropylene and Steel	Injection Molding
3	Back Leg Top	1	Aluminum	Aluminum Extrusion
4	Back Leg Middle	1	Aluminum	Aluminum Extrusion
5	Bench Seat Release Button	1	Polypropylene	Injection Molding
6	Back Leg Button	1	Polypropylene	Injection Molding
7	Back Leg Bottom	1	Aluminum	Aluminum Extrusion and Welding

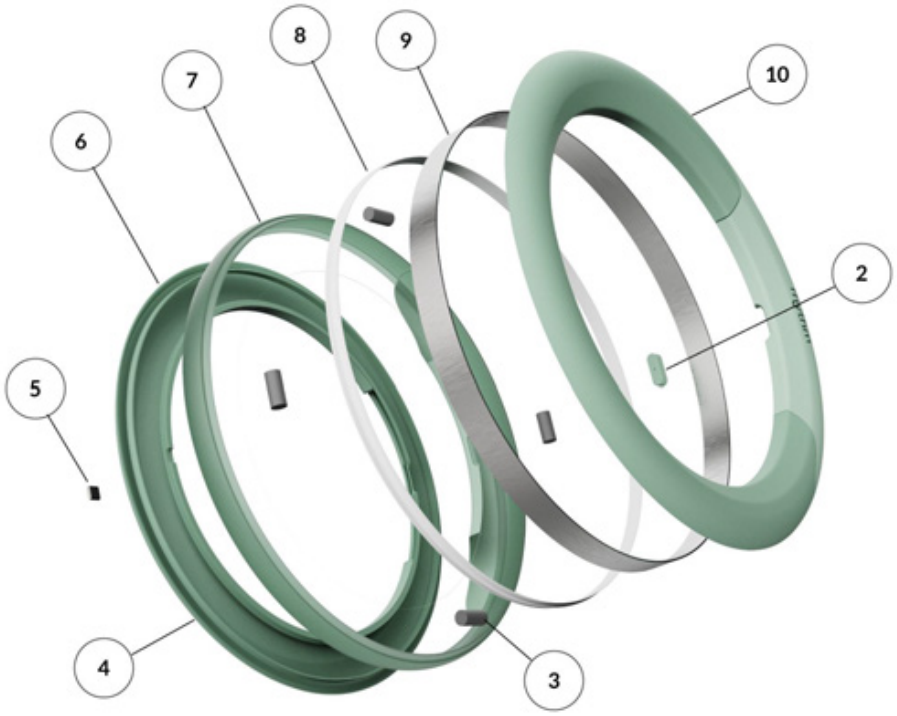


Table 16: Ring BOM

Part #	Description	Quantity	Material	Manufacturing Method
1	Handle Top	1	TPU Foam	Extrusion
2	Handle Mechanism	2	Polypropylene and Steel	Injection Molding
3	Back Leg Top	1	Aluminum	Aluminum Extrusion
4	Back Leg Middle	1	Aluminum	Aluminum Extrusion
5	Bench Seat Release Button	1	Polypropylene	Injection Molding
6	Back Leg Button	1	Polypropylene	Injection Molding
7	Back Leg Bottom	1	Aluminum	Aluminum Extrusion and Welding

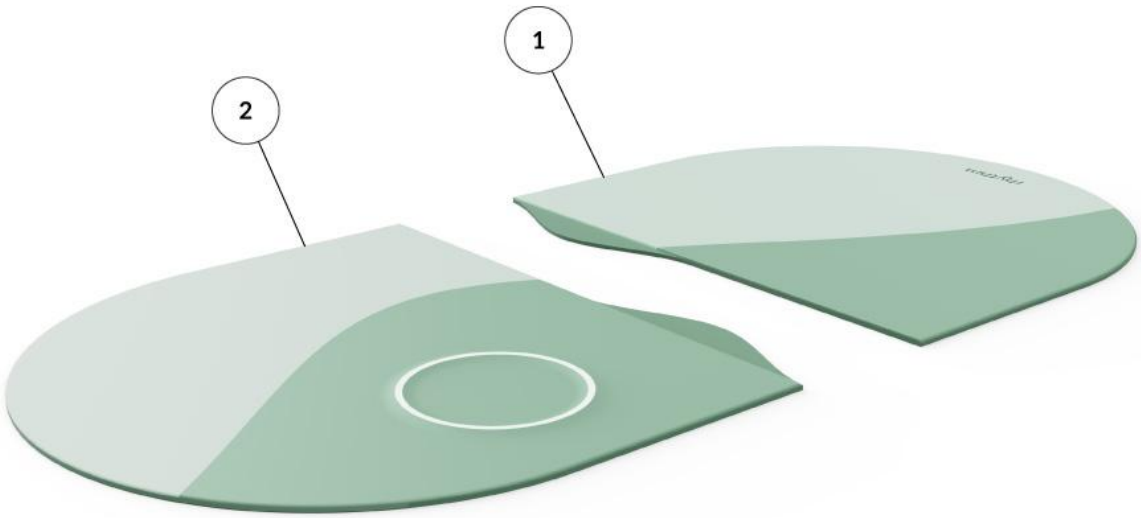
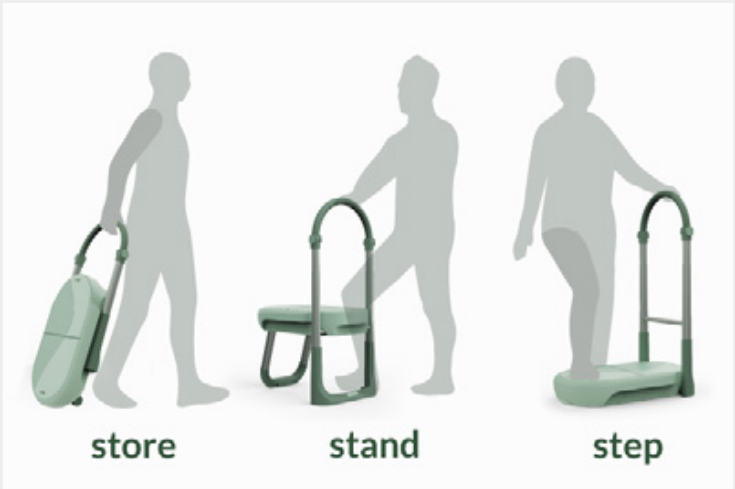


Table 17: Mat BOM

Part #	Description	Quantity	Material	Manufacturing Method
1	Mat Right Side	1	TPE and Robotic Fabric	Woven
2	Mat Left Side	2	TPE and Robotic Fabric	Woven

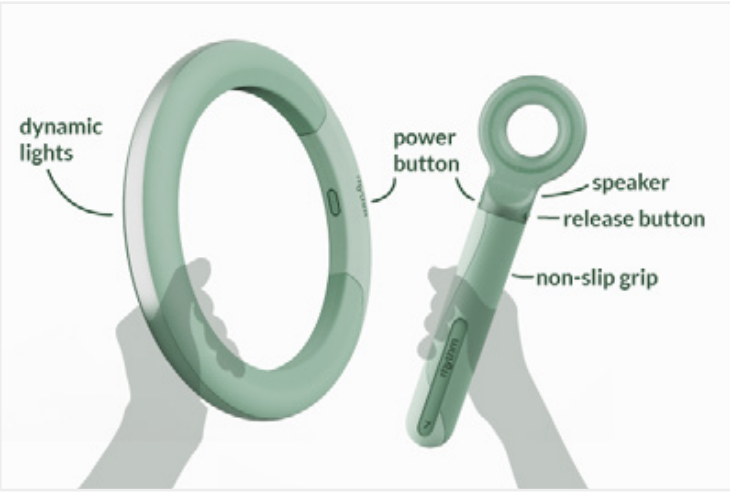
5.3 Final CAD Rendering

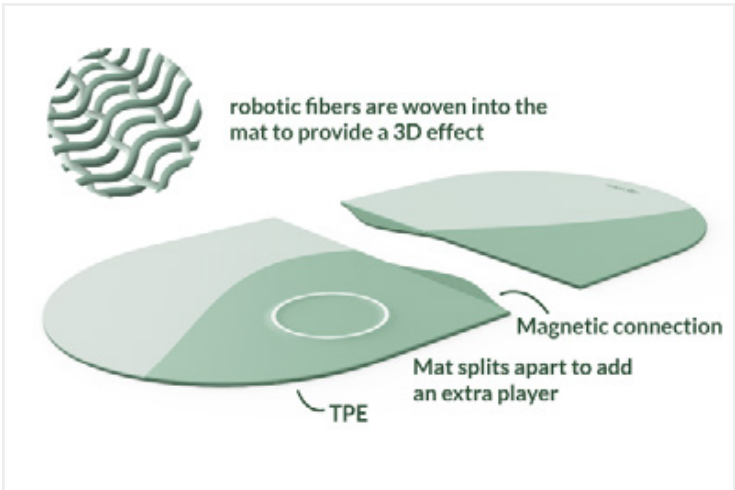

rhythm
rhythm
rhythm


store
stand
step


Robotic fibers in mat can smart detect objects that are placed on them.
If the bench is placed on the mat this device's gameplay will be modified for the seated position.


push button to unlatch the base
adjustable handle bar
Foot push button for retracting handlebar.


dynamic lights
power button
speaker
release button
non-slip grip


robotic fibers are woven into the mat to provide a 3D effect
Magnetic connection
Mat splits apart to add an extra player
TPE


App can be used on tablet devices or cast to a TV

5.4 Physical Model

Rhythm Bench Physical Model Views

Front Bench Detail

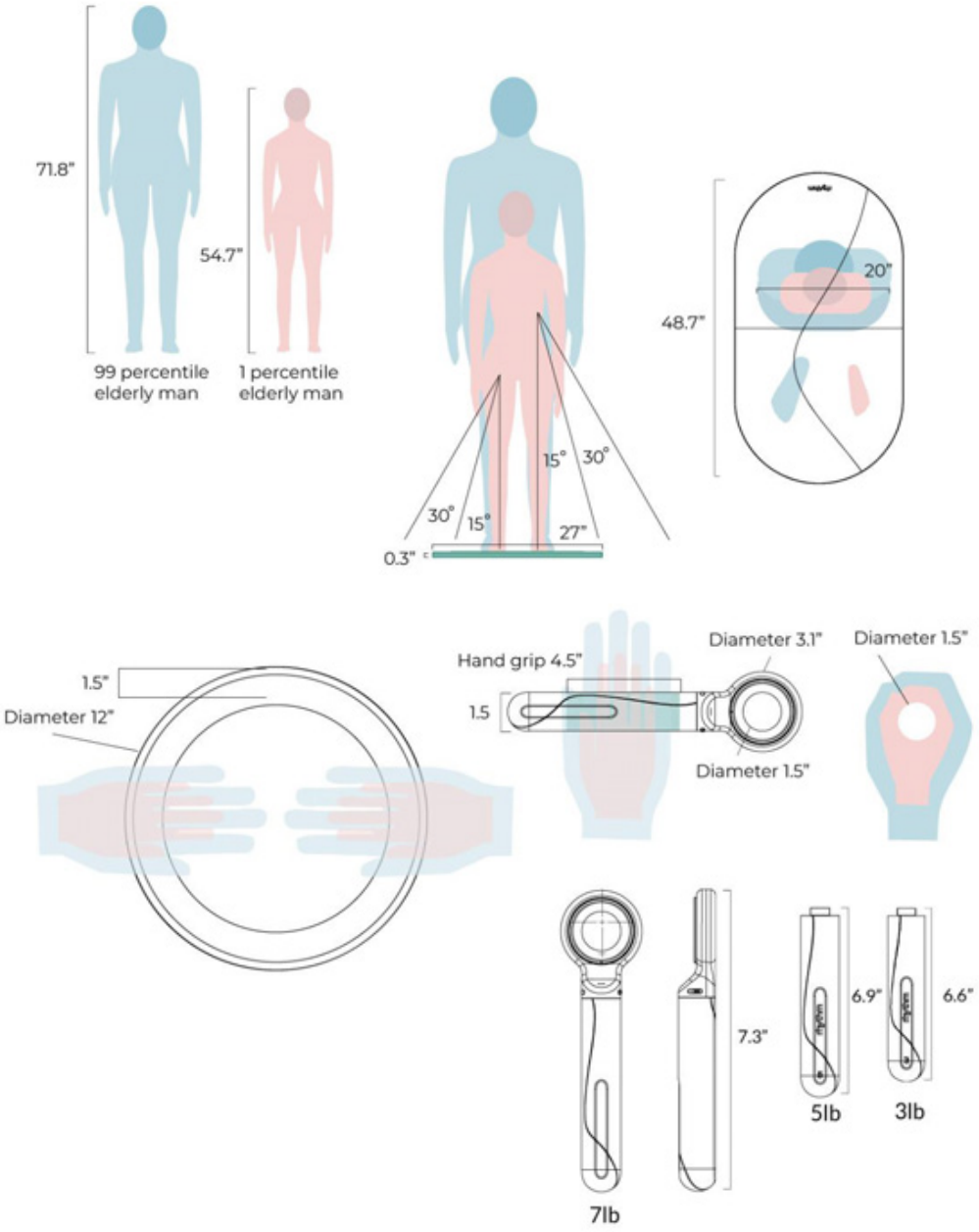
Back Bench Detail

Handle Detail

Tambourine Ring Detail

Maracas Dumbbell Detail

5.5 Technical Drawings



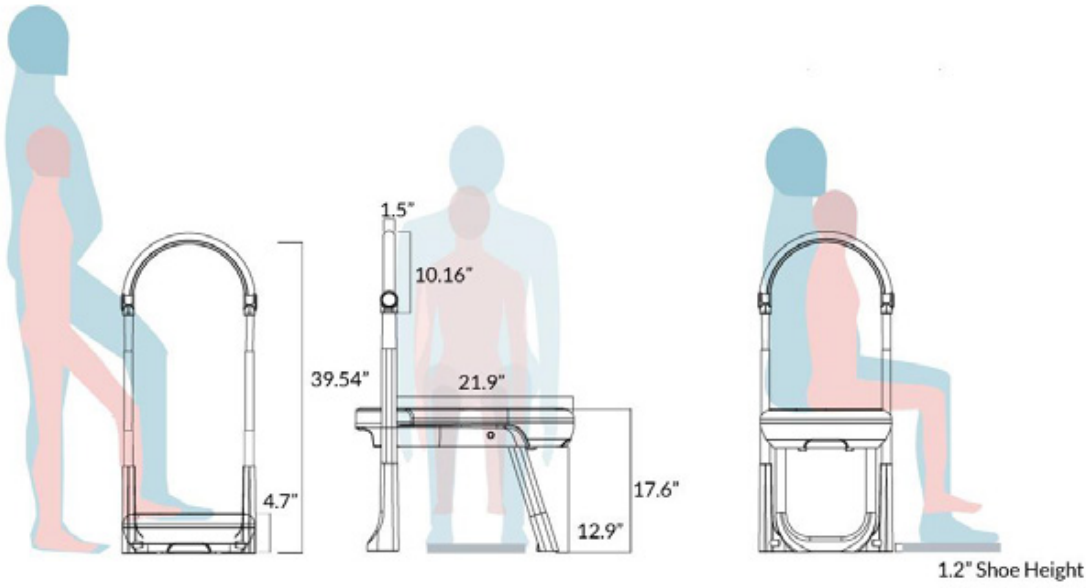


Figure 34: Project Schematic

5.6 Sustainability

The findings in this report helped to determine what types of materials would be best suited for the design project usability while also maintaining sustainability. Aluminum will be used for the frame of the workout bench because of its ability to be infinitely recycled, but also due to it being lightweight and easy for seniors to maneuver. TPU will be the primary material for the free weights due to its flexible but rigid properties. TPU is also more sustainable and easier to clean than silicone, which is difficult to recycle and not biodegradable. TPE will be used for the workout mat since the material is non-slip and flexible, but can be recycled and biodegrade the same as TPU. TPU/TPE are both biologically inert and do not pose any health risks to the user. Manufacturing processes and initiatives that could be implemented into the final design are recycling programs for the end-of-life of the products. The products can also be designed in a way that makes them repairable and easy to dissemble for recycling purposes. There is also the potential for using kinetic energy to charge the fitness equipment and developing a business model for the product that is carbon-neutral.

There is often a trade off that needs to be made between sustainability versus quality and usability of the product. The most sustainable materials may not have the desired properties or longevity required for a product and must be sacrificed. Even though the most desirable sustainable outcomes may not always be possible, the appropriate choice of material to limit environmental impact is still possible. Despite this, there are other ways to reduce the environmental waste and footprint of the product through initiatives and reducing carbon emissions or waste through the manufacturing process.

conclusion 06

Seniors' lifestyles have become more sedentary which makes them more susceptible to loss of their independence, loss of functional mobility, physical injury and other health risks. Seniors face a number of barriers to participating in physical exercise. Seniors fear becoming injured from exercising, fear of falling, do not find exercise enjoyable, or do not want to exercise alone. Rhythm is a smart and gamified fitness equipment set that is designed for seniors to address their ergonomic and safety needs. The Rhythm system is designed to be a fun, interactive and immersive experience that allows seniors to feel rewarded and fulfilled when they exercise. In addition, Rhythm is a social activity that can be played with a group or with friends. Rhythm provides an easy and simplistic way for seniors to strength train, which will improve their functional mobility and reduce muscle loss as they age.

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Lululemon Studio
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Unsplash. Old Woman in the Kitchen. https://unsplash.com/photos/ddKBuWekZr0
PrintingSociety/Adobe Stock

keenan/Adobe Stock
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Vectorry/Adobe Stock
avaicon/Adobe Stock
Kostiantyn/Adobe Stock
Robbiya/Adobe Stock
Nurachmadi/Adobe Stock

Appendix A: STEPVE Diagram

Appendix B: User Research

User Observation: Preliminary

Introduction

The objective of the preliminary user observation was to gain insights into the daily routines of seniors. To determine how seniors spend their time in retirement and what types of activities they participate in. The observation provides insights into their thoughts and feelings about their routines and differences in active versus inactive lifestyles.

Method

Data was collected using Youtube's search engine and entering search terms that related to the subject matter. After the videos for observation were identified, each video transcription was used

to code the videos. 6 codes were established after watching the videos used for observation and then the codes were applied to the transcript.

The following keywords were enter to find the videos used for observation:

- Day in the life of retirement
- Day in the life of a 70 year old
- Day in the life of a senior
- Senior life
- Senior exercising
- Senior routine

Results

What do I spend my time doing in retirement?
https://www.youtube.com/watch?v=baZZjS1pHA8&ab_channel=ReinventingU
July 17, 2019

Video Excerpt	Active Activities	Accomplished and positive Feelings	Negative Feelings and Fears	Social Activities	Cognitive Activities	Leisure Activities
"I really have to exercise in fact exercise plays a big part in my life whether I'm walking the dog practicing karate or even attending karate class you see me walking the dog and I have to say that if my dog does not exercise that it causes some problems in the family because she's very hyper and now that she has hyperthyroidism or some hyperthyroidism things hyperthyroidism it's even worse but anyway like yesterday I had not walked the dog and she snarled at one of the cats so in order to prevent some bad behavior she has to get exercise walking is very important exercising for me is important I think for everybody I always eat breakfast I do best if I walk before eating because I'm a very slowly digest food and if I eat then it's another hour or thirty minutes something before I can	make your bed every day I really have to exercise in fact exercise plays a big part in my life whether I'm walking the dog practicing karate or even attending if my dog does not exercise that it causes some problems in the family because she's very hyper I had not walked the dog walking is very important exercising for	accomplished one thing and it really does make a difference and your attitude the rest of the day	I hate housecleaning I try to do everything and then I get frustrated when things don't work or I've discovered something else needs to be cleaned	karate class work part-time	I spend some time in prayer and usually I have some other book a lot of times it's a secular book I usually read one chapter a day	after getting ready for the day there's time to work on the computer YouTube videos and time can get really get away from me at this point I usually leftovers or sandwich then I spend a few minutes reading so I sort of sort of a siesta vlog or social media and again I have to make sure I don't get

walk after getting ready for the day there's time to work on the computer and this might mean write a script for a video doing research responding to social media or even just watching a few YouTube videos and time can get really get away from me at this point sometimes I go to work part-time at a local fair trade store and those hours are 10:00 a.m. to 5:30 or 6:00 p.m. "	me is important I think for everybody I walk before Eating at a local fair trade store and those hours are 10:00 a.m. to 5:30 or 6:00 p.m do household chores and have I mentioned running some errands I clean up the kitchen					lost in cyberspace evenings are heavy on reading with an occasional family game night or watching something on Television we do more reading than watching television say although I have to say since my family's been out of town I watched a lot of television

I Tried My Grandma's Routine For A Day

youtube.com/watch?v=7TrN9vrIASo&ab_channel=As%2FIs

Nov 19, 2019

Video Excerpt	Active Activities	Accomplished and positive Feelings	Negative Feelings and Fears	Social Activities		Cognitive Activities	Leisure Activities
""- The popularity of this woman. Okay, well grandma, we just got a visitor. Who is this? - [Gladys] Say who you are. - Ben Krause. I'm gonna go play piano for the nursing home. (upbeat piano music) (clapping) - That was so nice. We just got out of the care home. Where we going now grandma? - We're going to Gambino's, eat some, eat some a, what are we gonna eat? (laughing) - I'm eating what you're eating. - No, no, no, you eat what you, I'm gonna eat what you're eating. - I have to be you. Okay. (laughs) Okay, so we finished eating, and I had two slices of pizza and one desert pizza, because that's exactly what you ate. - Yeah. - So, we're twins, so we might have to both	"she lives an incredibly active lifestyle. She's super involved in the church. She does things like teach pie making classes." "Is this a secret recipe? Should we not give it away? - No, no, no, no. - [Krista] No secret grandma Gladys recipes? - No, no, no. You think I'm really crafty, don't you? - [Krista] You're not? - [Gladys] No. - [Krista] So, this is the recipe she's using." "Where are we going grandma? - We're going to the cemetery, to visit the dead." "- Hey, I think you're a busier woman than I am."	"- [Krista] So, do you perfectly set the table like this before every meal? - [Gladys] That's not perfectly set. - [Krista] It just looks so nice. - Oh. It does? How do you do it? - [Krista] I don't." "- I'll put on-- - Put on our lipstick. - And I have to put on my clothes. See, I've just got on my undies. - Oh!" "We've done so much. - Yeah, we made a lot of tracks today, didn't we? - We did." "Then, when I get up in the morning, I don't have to do anything, it's just all ready to go." "to sit down and appreciate	"Well, I don't want anybody to see that bald spot back there."	"You can't go anywhere, without anybody stopping and talking to her" " [Krista] Okay, so your hair's all shampooed,." "So, you do it once a week, every Thursday?" "- My grandma's so popular that she had two voicemails. I heard her checking them, and now she's on the phone with somebody, already making plans." "- The popularity of this woman. Okay, well grandma, we just got a visitor. Who is this?" "I'm gonna go play piano for the nursing home. (upbeat piano music) (clapping) - That was so nice.	"- I'm here for dinner, yes with my mom, 'cause she's the best cook ever. - So, you came-- - And pie. - [Krista] After work to eat, so you could get a free meal out of her? - Yeah, that's what I did." "And I go to church." "And I go to the old lady card club." "and spending time with your friends and your family, and the people that care about you."		"Now, first thing we do is pray. Father, Son, Holy Ghost," "- Well, I usually watch "The View". - All right, so we're gonna sit back and watch "The View"." "- We're gonna take a nap, to let our food digest."

poop at the same time. Maybe. - Yeah, yeah. (laughing) And now we're gonna take a nap. - We're gonna take a nap, to let our food digest. - And then we're gonna make some pie. - No joke, it's been a busy day, and I honest feel like I kinda need a nap. And I usually don't take one.””	“I go to the store all the time. And I go to the college gardens.” “I go to the library.”	each moment. And I really feel like my grandma lives in the moment.” “has made me realize the importance of slowing down and appreciating the moment you're in,” “I'm gonna go to the nursing home, but now I don't say it anymore.”		We just got out of the care home. Where we going now grandma?” “Okay, so we finished eating, and I had two slices of pizza and one desert pizza, because that's exactly what you ate. - Yeah.”		

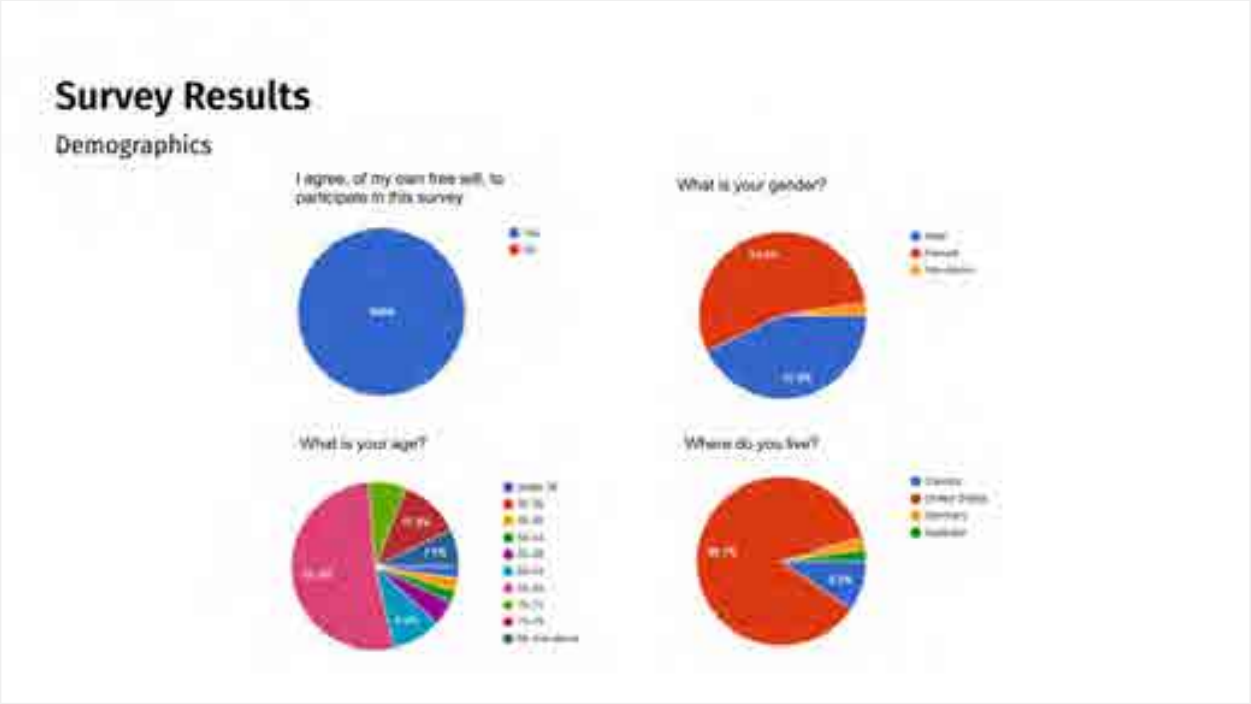
What Life Is Like In A Nursing Home

https://www.youtube.com/watch?v=Z7f5xkucTA0&ab_channel=BuzzFeedVideo

Sept 4, 2018

Video Excerpt	Active Activities	Accomplished and positive Feelings	Negative Feelings and Fears	Social Activities	Cognitive Activities	Leisure Activities
““- I feel the elderly are neglected a lot by their own families, and it's sad because elderly kind of want to have their own family around. - I have some family members who don't even visit, and that's the sad part and sometime we try to call them, to speak to them, they don't even answer the phone. - I haven't been happy since my wife died, my daughter died, and my son ran off with all the money. So, ain't been too many happy days. - That's one of the things, it really hurt me deep inside. Just take the moment and come and visit your parents. If it was the other way around, your parents would come and visit you. One parent can take care of 10 kids, 10 kids cannot take care of one parent. - When I was living on my own, I used to celebrate the holidays, and I would always call up nursing homes and ask them to please send me a few of their people, so that their people could then	“[Sitting exercises with nursing home patients] - One. Two. (clapping) Three. Four. - [Woman] Good job. - Five. - Six.”	“- Taking care of the elderly is very rewarding, especially when they improve.” “Now, thank God she's eating, walking, and talking. And she's so happy.” “- When I was living on my own, I used to celebrate the holidays, and I would always call up nursing homes and ask them to please send me a few of their people, so that their people could then enjoy the holidays to their fullest and not spend it lonely in a room by themselves.”	“it's hard to watch and to know that it's just a matter of time before I get there, before my mother gets there,” “When she first moved into our place, she was not able to walk, or talk, or eat even.” “- The challenge in this job, it is when people decline. And they actually see how they deteriorate, you find yourself being really helpless.” “- I feel the elderly are neglected a lot by their own families, and it's sad because elderly kind of want to have their own family around. - I have some family members who don't even visit, and that's the sad part and sometime we try to call them, to speak to them, they don't even answer the phone. - I haven't been happy since my wife died, my daughter died, and my son ran off with all the money. So, ain't been too many happy	“ have a conversation with them, spend 10-15 minutes with them and you will see how much they thrive.”	“- This was my hobby of making beaded flowers.” “- What letter is that? - [Man] H. - That's right. And this one is? - I. - In the afternoon, basically we do bingo, puzzles, arts and craft, because it's very good for their cognitive skills.”	“How are you, Mama? [client lying on the couch with a blanket over her] How is everything? - Most things are okay.” “♪ I'm gonna let it shine ♪ ♪ Everywhere I go, I'm gonna let it shine ♪”

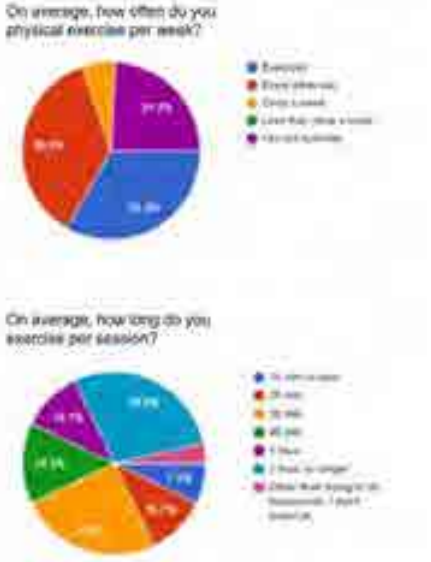
enjoy the holidays to their fullest and not spend it lonely in a room by themselves. Please remember the elders, because they have contributed so much to all of our lives.""			days." "Just take the moment and come and visit your parents. If it was the other way around," ""No, just please, if you could come and talk to me. ""			



Survey Results

Seniors 65+

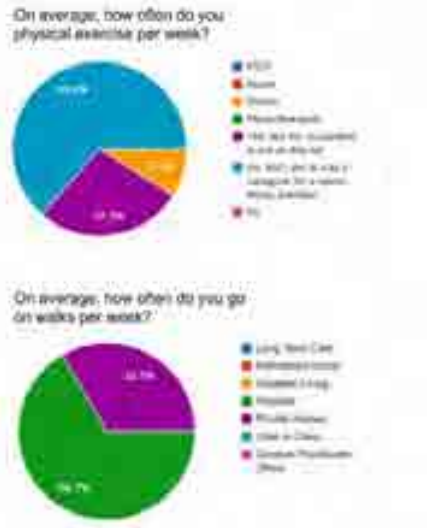
- **33 of 42 Respondents were 65+**
- **39% of seniors said walking was part of their fitness routine**
- Some seniors cited **active activities they did as part of their fitness routine**, like volunteering or walking the dog
- Seniors said **motivation, weather, flexibility, pain and finding time made** exercising difficult for them
- 39% of seniors said they used traditional fitness equipment (weights, resistance bands, elliptical, etc). Others did not use equipment or they used other devices to help them with their workouts, like fitbits, heating pads, or a kitchen chair
- Majority of respondents said they wanted to **maintain good health, balance, mobility, and/or strength when exercising**
- Seniors with issues with their mobility, many said **going up and down stairs and standing up from sitting** caused them issues
- Seniors also discussed getting out of bed and activities where they need to balance as causing them issues
- **"The difficulty with exercising is how easy it is to get hurt and how long it takes to recover.** I use to use 18 and 20 kg kettle bells. Now, after several low back and shoulder injuries, I limit myself to 8kg bells even though I could work out with heavier bells. The risk is not worth it."
- 24% of seniors said they used assistive mobility devices and the majority used canes or hiking poles

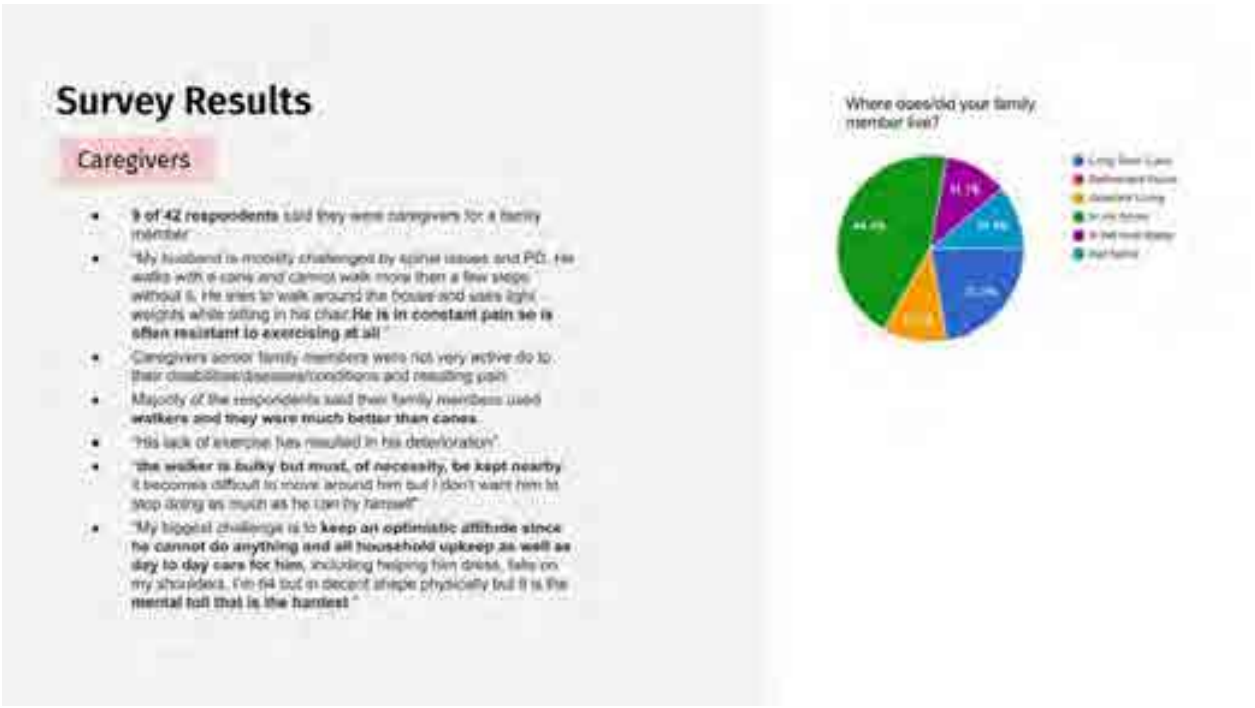


Survey Results

Healthcare Workers

- **3 of 42 Respondents** worked in Healthcare
- "**Its hard to go for a walk in western Canada when its' icy and snowy** for 6 months a year, so they need to find a place where they can exercise safely."
- Common challenges: "Chronic pain, muscle loss (sarcopenia), frailty fear of falling, **lack of availability of support** (such as a physiotherapist), poor cognition"
- "**Diseases like arthritis** make it hard to move comfortably and its discouraging to move when you know it will hurt at least for the first few minutes. Balance is changed and its harder to walk on uneven surfaces and stairs."
- Common devices used: "**Walking is very popular** and can be very social. Many play pickleball and other league games." "Most don't use any devices"
- "Most injuries I've seen are from falls and **most result in broken bones** (I work in a hospital). This reduces their mobility further until they recover and its' even more difficult to get back to exercising"
- "**Fractures (especially hip)**, intracranial hemorrhage, soft tissue/skin lacerations, skin tears"
- Trends you see happening: "(1) Care in the community setting (rather than hospital), 2) Telehealth-based assessments, 3) reduction in psychotropic medications"

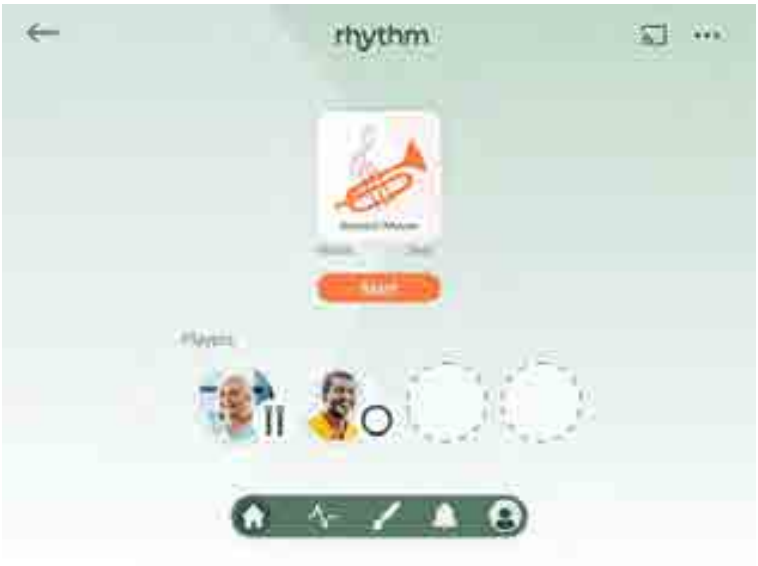




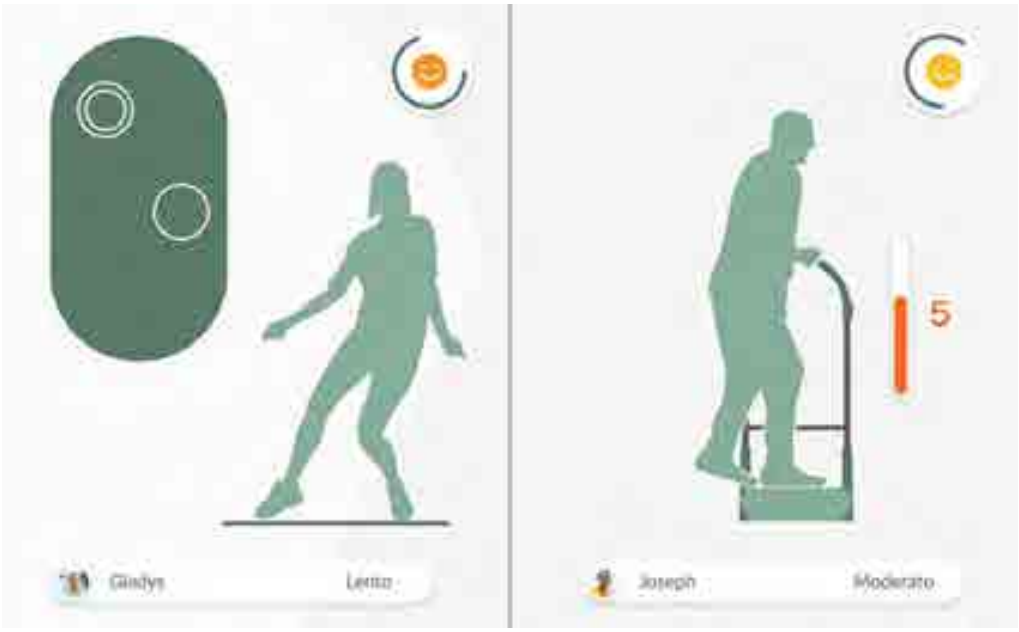
Appendix C: Rhythm Application

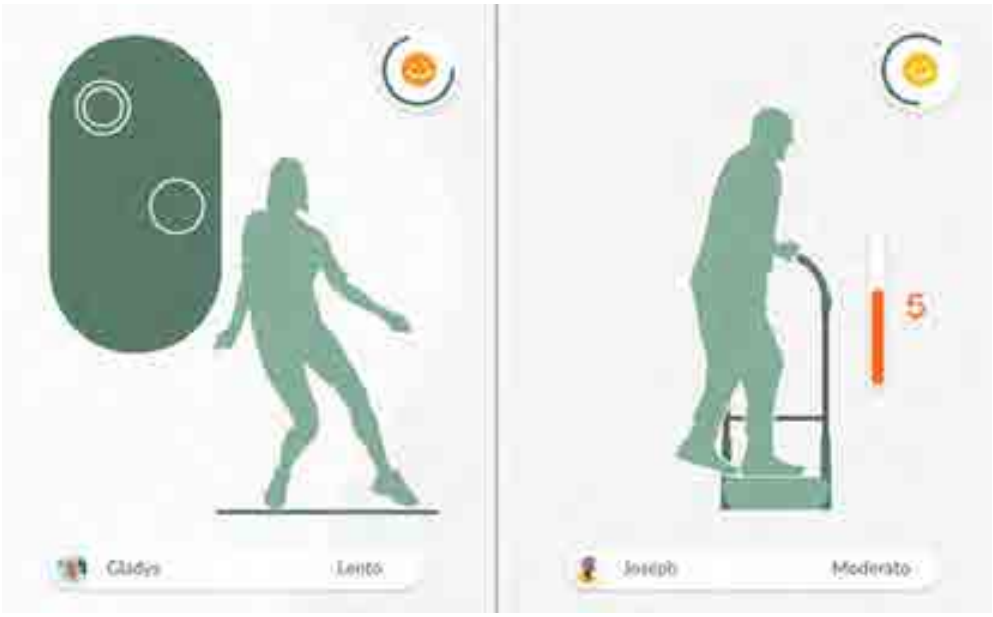

rhythm
Band Mode
Party Mode
Freeplay
Practice
Try out workouts created by the rhythm community
Continue playing
This Week
Smooth Moves
Dreamy Disco
Funky Tr


+5
Gladys
Lento
+3
Joseph
Moderato


rhythm


5
Gladys
Lento
hold it!
Joseph
Moderato
Gladys
Lento
4
Joseph
Moderato





Appendix D: Approval Forms & Plans

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

Melissa Stocco

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Certificate # 0000265674

Date of Issue: **3 May, 2016**

THESIS TOPIC APPROVAL

Student Name:	Melissa Stocco
Topic Title:	How may we improve the physical health and mobility of sedentary seniors?

TOPIC DESCRIPTIVE SUMMARY (PRELIMINARY ABSTRACT)

Canada's largest generational group, Baby Boomers, will all be over the age of 65 by 2030. Seniors are living longer so they will require more medical care and healthcare services as they get older. As adults age, they experience a reduction in bone density and muscle loss which can make them frail. Frailty makes seniors more likely to fall doing daily tasks and break bones. Seniors' can improve physical health and reduce their bone and muscle loss by participating in light exercise everyday, totalling to at least 150 min per week. Statistics Canada (2022) reported that in 2021 only 40% of adults 65 year and older completed the minimum recommended amount of exercise per week. Seniors suffer barriers to exercising like fear of falling, not knowing how to perform workouts, feeling vulnerable, and worrying about being too active. Seniors can also face physical disabilities that make it more difficult to exercise and require modified workout routines. This thesis project will research how older adults stay physically active, barriers they face to being active, and ways tools can improve their activity levels and physical mobility. This study will consist of surveys, interviews, and observations of the different stakeholders involved including seniors, medical professionals, and caregivers. The research from this study will provide insights to design a product or solution that will help older adults be physically active, motivate adults to participate in physical activity, and improve their overall mobility.

Student Signature(s)	
Date	09/27/22

Instructor Signatures	
Date	06 October 2022

IDSN 4502
SENIOR LEVEL THESIS TWO

Humber ITAL / Faculty of Applied Sciences & Technology
Bachelor of Industrial Design / WINTER 2023
Catherine Chong / Fredric Matovu

CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION

Student Name:	Melissa Stocco
Approved Thesis Title:	Music-Inspired Fitness Solution for Seniors

THESIS PROJECT – DESIGN APPROVAL FORM

Design is reviewed and approved to proceed for the following:	[X] **CAD Design and Development Phase**
Comment:	Continue design refinement in CAD development, need to iron out detailing and product's features, pay attention to surfacing, components, and assembly methods for design feasibility. Viable holistic design thinking in conjunction with considerations into sustainability aspects. CAD development must be at least 75% complete for review before approval for fabrication.

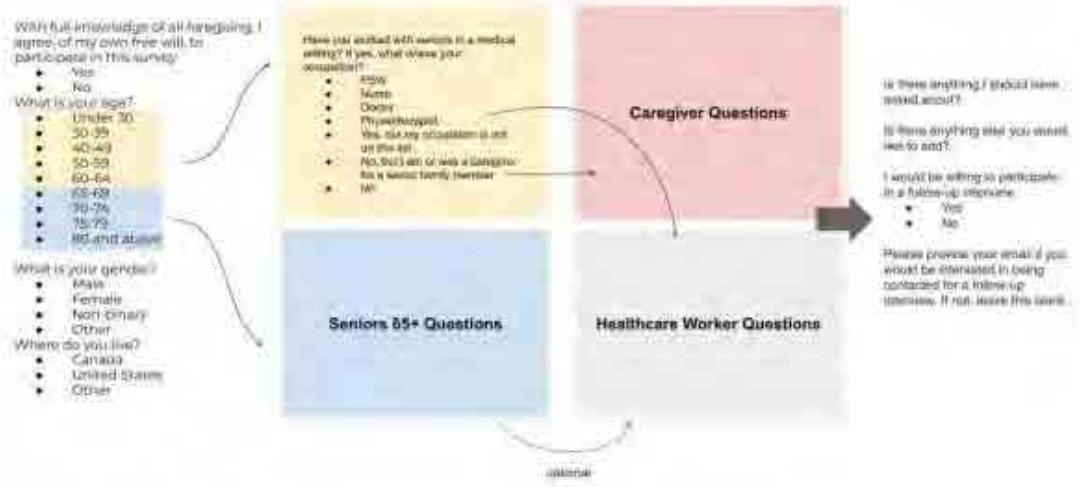
Design is reviewed and approved to proceed for the following:	[X] **Model Fabrication Including Rapid Prototyping / 3D Printing and Model Building Phase**
Comment:	Waiting for CAD development review (as of Feb-21). Good progress with CAD, design completed, continue detail refinement, once refined, fabrication of model can begin.

Instructor Signature(s):	Catherine Chong F.K. Matovu
Date:	07 March 2023

Research Methods

Exploratory Survey

Survey Overview



Seniors 65+ Questions

On average, how often do you physical exercise per week?

- Everyday
- Every other day
- Once a week
- Less than once a week
- I do not exercise

On average, how long do you exercise per session?

- 10 min or less
- 20 min
- 30 min
- 40 min
- 1 hour
- 1 hour or longer
- Other

What types of exercises or activities are a part of your fitness routine?

On average, how often do you go on walks per week?

- Everyday
- Every other day
- Once a week
- I do not go on walks

Caregiver Questions

What is the most difficult part of exercising for you?

What fitness devices do you use? What do you like or dislike about them?

What do you hope to get out of exercising?

Do you find any difficulty with your mobility? Are there tasks you used to do easily but now find more difficult? (i.e. getting up from chairs, going up stairs, etc.). How do you feel about that?

Do you have any physical disabilities that limit your mobility? How does this affect your ability to exercise?

Do you use assistive mobility devices? (i.e cane, walker, etc). What do you like or dislike about them?

Do you or did you work with Seniors 65+ in a medical field? (i.e. doctor, PSW, nurse, physiotherapist, etc)

- Yes
- Yes, but I am retired
- No

Healthcare Worker Questions

Where does/did your family member live?
- Long Term Care
- Retirement Home
- Assisted Living
- In my home
- Other

What challenges do you see your family member face when trying to exercise regularly?

Does your family member use any fitness devices to exercise? How effective are these devices? What do you like or dislike?

What mobility issues does your family member have?

What assistive mobility devices does your family member use (i.e. cane, walker, chair lift)? How effective are these devices? What do you like or dislike?

What challenges do you face when caring for your family member?

What type of facility do you work in?
- Long Term Care
- Retirement Home
- Assisted Living
- Hospital
- Private Homes
- Walk-in Clinic
- General Practitioner Office
- Other

What common challenges do you see seniors face when trying to exercise regularly?

What common mobility issues do seniors have?

What are the most common assistive mobility devices used by seniors? How effective are these devices? What do you like or dislike?

What are the most common fitness devices used by seniors? How effective are these devices? What do you like or dislike?

What are the most common injuries seniors sustain? How are these injuries prevented?

What are the top 3 trends you see happening in geriatric care?

Have you been a caregiver for an adult over the age of 65?
- Yes
- No

Interview Questions

Senior Interview Questions:

Demographic Questions

- What is your age?
- Where do you live?
- What is your gender?

Physical Health Questions

- On average, how often do you do physical exercise per week?
- On average, how long do you exercise per session?
- What types of exercises or activities are a part of your fitness routine?
- What are the top three challenges that you experience with your mobility and health as you age?
- Have you experienced any injuries that have affected your mobility in the last 5 years?
- Do you have any physical disabilities that limit your mobility? How does this affect your ability to exercise?
- Do you use assistive mobility devices? (i.e cane, walker, etc). What do you like or dislike about them?
- Do you see any trends affecting older adults' physical health in the past 5 years? What health issues do you find affecting people

- On average, how often do you go on walks per week?
- What is the most difficult part of exercising for you?
- What fitness devices do you use? What do you like or dislike about them?
- Do you find any difficulty with your mobility? Are there tasks you used to do easily but now find more difficult? (i.e. getting up from chairs, going up stairs, etc.)
- around you?
- Do you see any new technology trends in the past 5 years that have helped you or your friends improve their physical health or mobility
- What opportunities do you see for the improvement of older adults' physical health and mobility?
- Do you know anyone I could follow up with? Is there anything you think I should have asked about?

Senior Interview Questions (Revised):

Demographic Questions

- What is your age?
- Where do you live?
- What is your gender?

Physical Health Questions

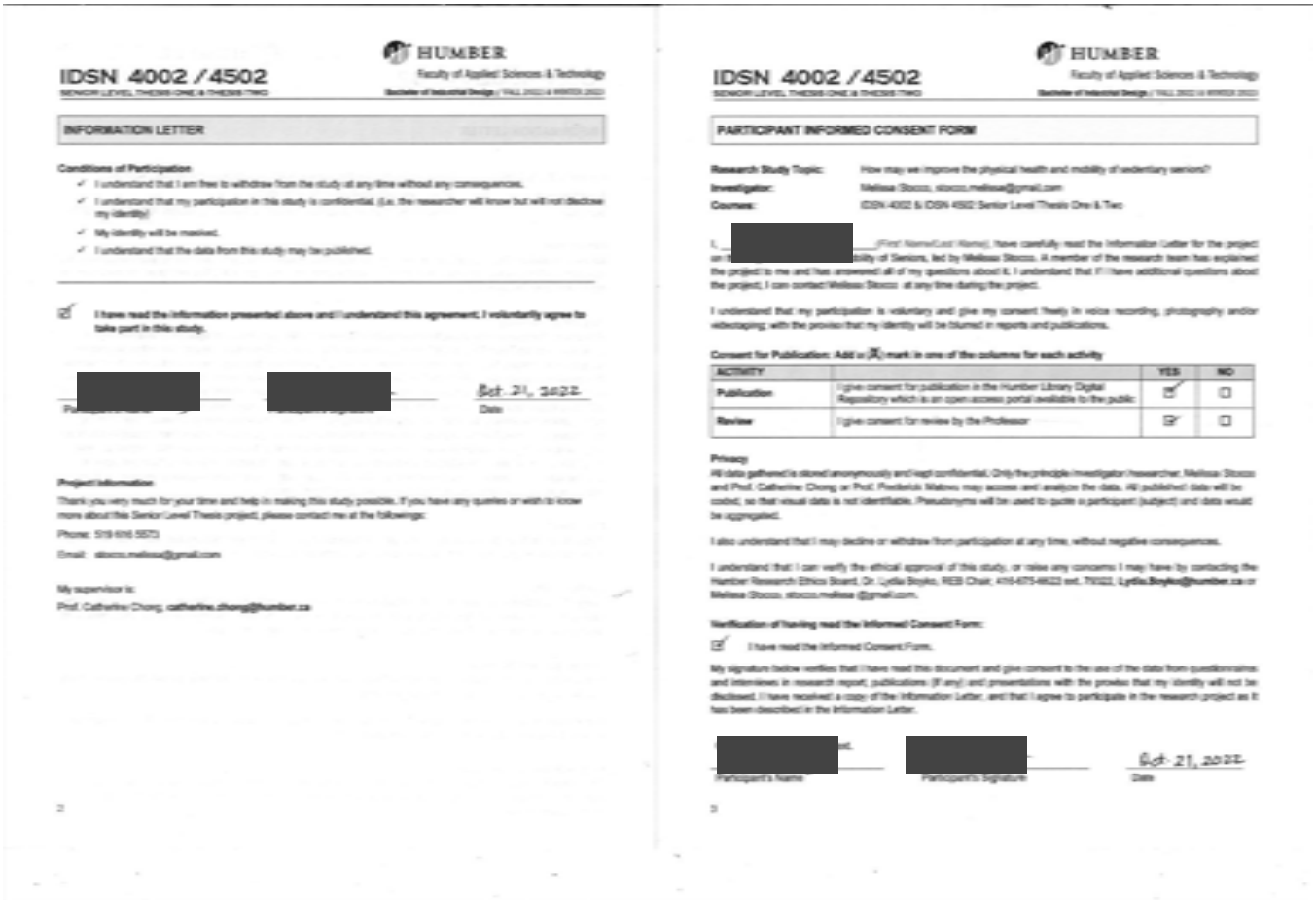
- How many people live in your household?
- What does a typical day look like for you? What is your daily routine?
- What types of activities do you participate in your daily life? Why do you like participating in these activities?
- What type of transportation do you use to get to your activities? (walking, driving, public transportation etc.)
- How do you spend your leisure time (i.e reading, television)?
- How does weather impact your ability to exercise?
- What do you use the internet for? What types of devices do you use? Do you use the internet to help you with exercise? (i.e for advice or watching videos)
- Why don't you use fitness devices?
- On average, how often do you go on walks per week?
- Do you exercise? What types of exercises or activities are a part of your routine?
- On average, how often do you do physical exercise per week and how long do you exercise per session?
- What is the most difficult part of exercising for you?
- How have your fitness levels changed as you have aged? Why did these changes happen?
- Do you use fitness devices? What do you like or dislike about them? If you don't use fitness devices why not?
- Do you find any difficulty with your mobility? Are there tasks you used to do easily but now find more difficult? (i.e. getting up from chairs, going up stairs, etc.)
- Have you experienced any injuries that have affected your mobility in the last 5 years?
- Do you use assistive mobility devices? (i.e cane, walker, etc). What do you like or dislike about them?
- Do you know anyone I could follow up with? Is there anything you think I should have asked about?

Physiotherapist Interview Questions:

Occupation Questions

- How long have you been working as a physiotherapist?
- What type of facility do you work in? (i.e. hospital, LTC, private clinic, etc). What are the demographics of your clientele?
- What types of goals do seniors have when they visit physiotherapy? (Are they trying to become fit, lose weight, or maintain mobility?)
- What are the most common injuries you see seniors sustain? How could these injuries be prevented?
- What common challenges do you see seniors face when trying to exercise or perform physio exercises?
- What common mobility issues do seniors have? How do you treat those issues?
- How motivated are seniors to complete physio exercises? Do they complete the assigned exercises? Do you typically see improvement in their physical health?
- Do you have any techniques to motivate seniors to perform exercises?
- Do any of your senior patients use assistive mobility devices? How does that affect their treatment?
- What types of fitness equipment do you use for seniors? Do any of your patients have exercise equipment they use at home?
- Do you see any trends affecting older adults' physical health in the past 5 years?
- Do you see any new technology trends in your field in the past 5 years?
- What opportunities do you see for the improvement of older adults' physical health and mobility?
- Do you know anyone I could follow up with? Is there anything you think I should have asked about?

Appendix E: Advisor Meetings and Agreement Forms



HUMBER
Faculty of Applied Sciences & Technology

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

INFORMATION LETTER

Conditions of Participation

- ✓ I understand that I am free to withdraw from the study at any time without any consequences.
- ✓ I understand that my participation in this study is confidential. (i.e. the researcher will know but will not disclose my identity)
- ✓ My identity will be masked.
- ✓ I understand that the data from this study may be published.

☑ **I have read the information presented above and I understand this agreement. I voluntarily agree to take part in this study.**

[redacted] [redacted] Oct. 21, 2022
Date

Project Information

Thank you very much for your time and help in making this study possible. If you have any queries or wish to know more about this Senior Level Thesis project, please contact me at the followings:

Phone: 519 616 5573

Email: stocco.melissa@gmail.com

My supervisor is:

Prof. Catherine Chong, **catherine.chong@humber.ca**

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HUMBER
Faculty of Applied Sciences & Technology

IDSN 4002 /4502
SENIOR LEVEL THESIS ONE & THESIS TWO

PARTICIPANT INFORMED CONSENT FORM

Research Study Topic: How may we improve the physical health and mobility of sedentary seniors?
Investigator: Melissa Stocco, stocco.melissa@gmail.com
Courses: IDSN 4002 & IDSN 4502 Senior Level Thesis One & Two

I, [redacted] (First Name/Last Name), have carefully read the Information Letter for the project on the [redacted]bility of Seniors, led by Melissa Stocco. A member of the research team has explained the project to me and has answered all of my questions about it. I understand that if I have additional questions about the project, I can contact Melissa Stocco at any time during the project.

I understand that my participation is voluntary and give my consent freely in voice recording, photography and/or videotaping, with the proviso that my identity will be blurred in reports and publications.

Consent for Publication: Add a [X] mark in one of the columns for each activity

ACTIVITY		YES	NO
Publication	I give consent for publication in the Humber Library Digital Repository which is an open access portal available to the public:	☑	☐
Review	I give consent for review by the Professor	☑	☐

Privacy

All data gathered is stored anonymously and kept confidential. Only the principle investigator / researcher, Melissa Stocco and Prof. Catherine Chong or Prof. Frederick Walowy may access and analyze the data. All published data will be coded, so that visual data is not identifiable. Pseudonyms will be used to quote a participant (subject) and data would be aggregated.

I also understand that I may decline or withdraw from participation at any time, without negative consequences.

I understand that I can verify the ethical approval of this study, or raise any concerns I may have by contacting the Humber Research Ethics Board, Dr. Lydia Boyko, REB Chair, 416-675-6622 ext. 79322, **Lydia.Boyko@humber.ca** or Melissa Stocco, stocco.melissa @gmail.com.

Verification of having read the Informed Consent Form:

☑ I have read the Informed Consent Form.

My signature below verifies that I have read this document and give consent to the use of the data from questionnaires and interviews in research report, publications (if any) and presentations with the proviso that my identity will not be disclosed. I have received a copy of the Information Letter, and that I agree to participate in the research project as it has been described in the Information Letter.

[redacted] [redacted] Oct. 21, 2022
Participant's Name Participant's Signature Date

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[redacted] Sat, Mar 4, 11:00 AM

Hi Melissa,

First, I love the concept of a packable gym for seniors that offers a variety of exercise modalities. Second, a music-based (and themed) workout will help motivate seniors to move. The lights, robotic fabric, bench storage are all icing on the cake. Amazing ideas!

Some questions:

1) How is music integrated in the equipment? Is there a way to use the equipment with the music "sans" an app? What are the music options for seniors? How tech savvy must one be to use this system?

2) I assume that the app will provide instructions and exercises for a full body workout. Will there be videos and trainers?

3) Safety is usually the number one concern in exercise training. For example, the tambourine ring's sleeve. How does it insert and how much weight can be inserted? Is the tambourine flexible enough to push and pull with it? If so, it's a great tool. The bench looks lightweight and flimsy. How much weight can the bench hold?

4) Dumbbell Maracas: How many pieces - 2 only or 4? Which leads to my next question, the 3 sets at 1, 3 & 5 lbs may be fine for a 80 year old female beginner but for a male, it may need to be 3, 5 & 8 lbs (?). What about the eventuality of progressive overloading...can a 3 lb weight be added to a 5 lb weight for both hands, therefore 8 lbs in each hand?

4) For beginner seniors, I think this set will work well. Could there be an option to add-on the weight. It's possible that seniors may plateau/peak at a certain weight but others may progress and require more weight? The connectivity of the dumbbells is a great idea. Would putting 2 dumbbells together be long enough for a bench/chest press?

5) Fitness mat drums: Robotic fabric with embedded lights is very cool! Will the lights pop up randomly? We lose foot speed as we age so this is a great tool, especially if tempo is changeable/adjustable.

6) Fitness Bench: Almost all upper body exercises can be done seated (presses, curls, extensions) and tricep dips, sit to stand (squats), and bench assisted bent-over rows. I like the idea that the bench can be adjusted to the floor (step ups, heel raises/lowers). The bench does look unstable, like it may tip to the side. Also, is the base of the bench long enough for a person's torso and head to rest on the length of the bench? Can the bench incline? I like the hand rests and the packability. With everything, how much will this fitness system weigh?

7) What is the target demographic? Will it be affordable and how can you convince a senior to buy it and use it with all its bells and whistles? I actually can see young children liking this system.

Building and maintaining strength (muscle and bone) and mobility (joint strength) should always be the goal as we age. You have offered a variety of ways to do so with this high tech system. If looks like fun and if it is simple to use, the attraction will be there for seniors to purchase it. Integrating music is a motivator.

I like the concepts you've created for a fun and exciting workout. The maracas themselves are great for wheelchair bound seniors. The shareable mats are good, especially fitness is best enjoyed with others.

I hope my questions and comments are helpful.

Melissa S <[redacted]> Mar 4, 2023, 1:51 PM

[redacted]

Thank you for your thoughtful and detailed feedback [redacted]! Great questions and many things I will need to adjust and figure out going forward.

#1 & 2 I think it would be good to be able to use it without the app, it is a little 'futuristic' so there can be an assumption that future seniors will be more savvy, but it should still be easy to use. Yes the app would include instructions and training within it. I still have to design the app and need to get on it haha

#3 yes great feedback, I need to really rethink both the bench and the sleeve

#4 My target demographic I had as 65-75, so I will probably need to adjust the weight load

#5 the mat lights and 3d steps will correspond with the music in terms of frequency. Its a great idea to have different tempo levels for different users

#6 Yeah it is a good idea to make the bench longer. I wanted that but also wanted it to be compact to put away and not to be heavy. I am not sure how much the bench will weigh exactly, but the equipment right now is 20 pounds (With the Mats maybe getting closer to 25). It's definitely a concern. I know that everything being stored in the bench base could be a problem as well (being too heavy)

#7 Affordability is definitely a concern. I thought it could also be purchased by community centres or senior homes. But maybe the parts can also be bought individually to make it more accessible to individuals

I will give you and update next week or the week after! Thanks so much!

Melissa

Hi Melissa,

I wanted to add that 1 lb dumbbells are literally useless for resistance training. I'd either start at 2 lbs or 3 lbs and go up from there.

Attached is a picture of the Reebok deck bench with locking foot adjustments for a stable base. This may give you an idea of how you may design the base of the chair/bench. I have this bench and it's very versatile for workouts and is rated very high on Amazon.

Hope all is well!