Guideline of Outdoor Exercise Equipment for Elderly and Elderly with Disabilities

By

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Abstract

Aging causes a number of problems that can lead to physical health issues such as musculoskeletal problems in older adults and older adults with disabilities. This thesis examines the benefits of outdoor exercise for older adults and older adults with disabilities. The guide is selective, allowing designers to choose the parts of the body that need to be exercised and then choose different users such as older people or older disabled people. With this guide, designers will learn what to avoid and what to consider, laws and regulations, and some dimensions. With this tool, designers can create more comfortable and safe outdoor exercise equipment for seniors and older adults with disabilities.

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Chapter 1 Introduction

1.1 Problem Statement

Before work began on the Design Guidelines for Outdoor Exercises Equipment for Elderly and Elderly with Disabilities, preliminary survey of elderly and elderly with disabilities was conducted:

> Currently, it is estimated that 15% of the population worldwide or some 1 billion individuals live with one or more disabling conditions. More than 46 per cent of older persons – those aged 60 years and over—have disabilities and more than 250 million older people experience moderate to severe disability (*Department of Economic and Social Affairs Disability*, 2024).

At the same time, the world is ageing. "It is estimated that by 2060, the number of Americans aged 65 and older will increase from 46 million to more than 98 million" (*Health and Age-related Changes*, 2021). That means one-third of the U.S. population is older. As people in this category age or experience unexpected events, their lifestyles change and so do their normal outdoor activities.

From the current situation, there will be more and more older people and people with disabilities, but the outdoor exercise equipment on the market is not specifically designed for older people and older people with disabilities. Therefore, designers need to learn to make outdoor exercise equipment suitable for the elderly and the elderly people with disabilities, so that they can use the outdoor exercises equipment conveniently. Socialization features should also be added. According to statistics, nearly 25 percent of people in the United States between the ages of 65 and 74 suffer from hearing loss, and 50 percent of people over the age of 75 suffer from hearing

loss (*Age-Related Hearing Loss Presbycusis*, 2021). As a result of hearing loss, they often feel isolated and are vulnerable to depression and anxiety, which can lead to mental illness in older adults. Increased social functioning can increase social interactions and improve symptoms of depression and anxiety in the elderly.

Older people with disabilities and older people in general are less likely to be outdoors and socialize for other reasons or as they age. This leads to some changes in their physical or mental health. This can be a big problem for both the family and the community of these individuals. Learning how to design outdoor exercise equipment for the elderly and older people with disabilities will allow designers to create products so that they can enjoy the outdoors safely and happily.

1.2. Need for study

There are several things to learn when designing outdoor exercises equipment for older people with disabilities and elderly people:

Understanding the needs of the user is key to designing outdoor exercise equipment for older people with disabilities and elderly people. This includes considering factors such as physical limitations, balance, and visual or hearing impairments. Conducting a survey of target users, such as the one serving as the basis for this project, can provide a better understanding of their expectations and needs for outdoor exercise equipment.

Designers need to have a basic knowledge of anthropometrics and ergonomics, physics, psychology, and design methods and material. In order to provide a good outdoor activity for seniors and older people with disabilities, it is important to make sure that the outdoor exercise equipment is ergonomically designed for those users. Members of this group have different physical characteristics than the general population. It is important to ensure that they are safe and

comfortable during and at the end of their use of outdoor exercise equipment to satisfy the psychological fulfillment of the elderly and elderly with disabled. Ease of use and accessibility also need to be considered when designing outdoor exercise equipment for the elderly and elderly with disabilities. Outdoor exercise equipment for seniors and the elderly with disabilities need to be easy to maneuver and comply with accessibility principles.

Applying the lessons from anthropometrics and ergonomics, psychology, physics, and design methods and materials can prevent mental health problems caused by physical injuries to the elderly and elderly with disabilities when using outdoor exercise equipment.

1.3. Objective of study

The purpose of research into the design of outdoor exercise equipment for the elderly and elderly with disabilities is to provide more outdoor activity options that are suitable for their participation and promote their physical and mental health, social interaction, and quality of life.

First, the elderly and elderly with disabilities often face a range of physical or cognitive challenges that limit their ability to participate in traditional outdoor activities. They can be helped to overcome barriers and gain greater access to exercise opportunities through outdoor exercise equipment that is specifically designed to meet the needs of these groups. Such equipment may include wheelchair-friendly trails, accessible hiking facilities, fitness equipment with adjustable height and stability, and more. By using this guideline design to create outdoor exercise equipment, designers can ensure that seniors and elderly with disabilities can exercise safely and comfortably and enjoy the benefits that come with being in a natural environment.

Secondly, designing outdoor exercise equipment for the elderly and elderly people with disabilities can help improve their physical and mental health. According to scientific research, regular outdoor exercise can reduce the risk of chronic diseases such as cardiovascular disease,

obesity, and osteoporosis, and enhance the function of the immune system. In addition, breathing fresh air and exposure to sunlight in nature can help relieve stress, anxiety, and depression. Therefore, the design of outdoor exercise equipment for older persons and older persons with disabilities allows them to enjoy the natural environment and at the same time to have the opportunity to interact with others so that they are not isolated, thus changing their physical and mental health and cognition.

Third, there is also importance in terms of social interaction. Many older people feel lonely due to retirement or loss of a spouse; similarly, individuals with disabilities may face social isolation. Providing outdoor exercise equipment that is suitable for both groups to engage in common interests and to support and communicate with each other can promote interconnectedness and collegiality within the community. In such environments, the elderly and older people with disabilities can share experiences, form new friendships, and enjoy more opportunities for joint participation in community activities.

In conclusion, the study of designing outdoor exercise equipment for the elderly and older people with disabilities is out of concern and care for the needs of this group. It not only expands the types of activities they can participate in their daily lives, but also improves their quality of life and psychological state. In addition, it promotes the development of an inclusive community.

1.4. Assumptions

When designing outdoor exercise equipment for the elderly and older people with disabilities, we can think and imagine based on the following assumptions to ensure that this outdoor exercise equipment can meet their special needs and provide wider social and activity participation opportunities. Designers must understand that the priority of these different

assumptions will depend on the users, and consider factors such as safety, regulations, and unique needs of the users in order to consider each assumption in design.

Assumption 1: Existing outdoor exercise equipment is not suitable for the elderly and elderly with disabilities.

Assumption 2: The people reading this paper are industrial designers who know the design process and application.

Assumption 3: Elderly with disabilities can do outdoor exercise.

Assumption 4: Outdoor exercise equipment can help the elderly and elderly with disabilities improve their physical and mental health.

Assumption 5: The equipment can still be used by the elderly and the elderly with disabilities without changing the way they exercise on the existing outdoor exercise equipment.

Assumption 6: would the addition of semantics to outdoor exercise equipment make it easier for elderly people and elderly people with disabilities to exercise outdoors.

Through the above assumptions, designers reading this paper can grab what they need to create a more inclusive and beneficial outdoor exercise equipment.

1.5. Scope and Limit

1.5.1. Scope

All human data for this thesis were obtained from Henry Dreyfuss Associates and the ADA Standards. Based on these data, an analysis was performed to summarize some new data suitable for use in designing for older adults and older adults with disabilities.

Due to the diversity of older people and older people with disabilities and individual differences among users, it is not possible to design one type of outdoor exercise equipment to suit

all users. Therefore, people with special disabilities need to be observed and interviewed in a singular way, and people with special disabilities are excluded from the scope of this thesis study.

1.5.2 Limit

Only some anthropometric data is taken for this thesis. Wheelchair data is for standard manual wheelchairs; special wheelchairs and special aids are not discussed in this thesis.

This thesis considers the functionality, safety and security standards of outdoor exercise equipment for older adults and older adults with disabilities and does not address aesthetic aspects.

The design will be based on these ranges and full understanding these limitations to ensure the practical feasibility of designing outdoor exercise equipment and maximize the benefits for target users.

1.6. Anticipated Outcomes

The design of outdoor exercise equipment is mainly to provide more outdoor activity opportunities for the elderly and older people with disabilities to improve their quality of life. Designing outdoor exercise equipment for the elderly and older people with disabilities can bring many expected effects. Everything from physical health to social activities can be improved. Here are some possible expected effects.

- Improvement of physical health

Improvement of athletic ability: Appropriate outdoor exercise equipment can help the elderly and older people with disabilities gain physical fitness. For example: easy-to-operate outdoor exercise equipment can encourage them to engage in light or moderate outdoor exercise. It can improve cardiovascular health, increase muscle strength and physical flexibility to a certain extent in the elderly and older people with disabilities.

- Improvement of mental health

Reduce depression and anxiety: Outdoor exercise equipment is designed with the psychological needs of the elderly and older people with disabilities in mind. Through the integration of special products with the natural environment, the equipment can bring a pleasant outdoor activity experience to the elderly and older people with disabilities. A happy mood can reduce depression and anxiety in the elderly and older people with disabilities and has a positive impact on mental health.

- Increased social interaction

Create social opportunities: Participating in outdoor activities can increase opportunities for social interaction and can help the elderly and older people with disabilities more easily integrate into the community. For example, some multi-functional outdoor exercise equipment can be used by multiple people at the same time, which will promote friendship and social connections during the participation process.

- Improve the quality of life

Enhance the joy of life: Fun and challenging outdoor activities can allow the elderly and older people with disabilities to experience more joy in life. Positive joy in life can inspire the elderly and elderly with disabilities to increase their enthusiasm for life.

- Promoting Autonomy and Independence

Increased self-efficacy: Adaptable outdoor exercise equipment can help older adults and older people with disabilities feel empowered and autonomous when participating in outdoor activities. This increase in self-efficacy can help maintain their autonomy and independence.

- Improve body function and balance

Enhancing balance and coordination: Design for elderly and elderly with disabilities outdoor exercise equipment can be tailored to the specific needs of the elderly and elderly with disabilities. Helping them to improve their balance and coordination is important for preventing falls and increasing reliability in everyday life.

- Strengthening of social identity

Enhancement of social status: By designing outdoor exercise equipment for the elderly and the elderly with disabilities, we can convey society's respect and care for them and strengthen their sense of social identity, reducing the possible sense of social isolation.

By combining these factors, designing outdoor exercise equipment that meets the needs of seniors and older people with disabilities can provide them with an overall life-enhancing experience, enabling them to participate more actively in all aspects of life and society.

1.7. Definition of Terms

ADA Standard: The ADA Standards are accessible design standards and regulations that set forth requirements for the accessible design of a building or facility for persons with disabilities. Some of the definitions below are from the ADA Standards.

ASTM Standard: ASTM is the American Society for Testing and Materials. ASTM standards are developed by committees of related industry professionals who provide standards, test methods, specifications, guidelines, and practices. Some of the definitions below are taken from the ASTM Standards Guide.

Assistive devices: Canes, walkers, wheelchairs, and other mobility aids for the elderly.

Accessible: A relating to a part or portion of the outdoor fitness equipment that is approachable or usable, by persons of varying abilities.

Accessible route: pathway specifically intended to provide access for individuals with disabilities.

Applied handgrips: Handgrips that are formed, molded, or attached to a support, component, or structure.

Clearance space: Area beneath and immediately adjacent to outdoor fitness equipment that is designated for unrestricted circulation around the equipment and on whose surface, it is predicted that a user would land when falling from or exiting the equipment.

Crush point: Location between two moving components that when entered can cause a portion of the body to suffer a contusion, laceration, abrasion, amputation, or fracture.

CDC: Whole name Centers for Disease Control and Prevention is one of the major operating components of the Department of Health and Human Services. CDC is the nation's leading science-based, data-driven, service organization that protects the public's health.

Edge: Intersection of two planes or surfaces on a single component.

Foot support: A part of outdoor fitness equipment used to support all or part of the user's weight or strength during exercise.

Grip: grasping with the hands to avoid slipping or falling, holding an object with both hands for most of its circumference.

Outdoor exercise equipment: Product designed to be used in outdoor environments to promote various activities, exercises, or recreational activities, with the focus on increasing the frequency of outdoor activities for the elderly and older people with disabilities, enhancing physical and mental health, and improving quality of life.

Protrusion: a protrusion that is found to have the potential to cause bodily injury to the user who strikes it when tested as required by ADA standards.

Sharp edge: Edge that can cut a user's skin.

Sharp point/corner: Point or corner that can punch- tour or lacerate a user's skin.

Shear point: location at which parts move past one another or past a fixed point in such a manner that, when entered, can cause a portion of the body to become seriously injured in a scissors action between the components.

Step: Horizontal flat surface of a ladder or stair used primarily as a foot support.

Chapter 2 Literature Review

2.1. Benefits of Outdoor Activities for Elderly

In today's aging society, we need to focus on the physical and mental health of older people. Studies have shown that outdoor activities lead to a better quality of life. The natural environment has a moderating and restorative effect on the physical and mental health of older persons. Regular outdoor activity can delay the onset of aging and pathologies associated with common chronic diseases. Activity and exercise can improve balance and muscle strength and prevent accidental falls. “It seems fairly certain that (within limits) regular physical activity can fend off the aging process or its effects on the activities in our everyday life” (Haslegrave, 2006). Outdoor activities have also been linked to active living attitudes in older adults.

2.1.1. Physical Activity

“For older people, simply walking outside and staying outdoors for a brief time is beneficial. even non-aerobic activities have positive effects on well-being” (Wolf & Housley, 2018, pp. 4, 5). Wolf and Housley searched for some conclusions and results about the health benefits of outdoor activities for seniors. Here are some of their conclusions:

> For older adults, light exercise, such as taking short walks to a park or to do errands, greatly contributes to overall health. In a study of elderly people, those that had nearby parks, tree-lined streets, and space for taking walks showed higher longevity over a 5-year study period.
>
> In a long term study, participants going for a daily outdoor walk at age 70 reported significantly fewer new complaints at age 77 concerning musculoskeletal

pain, sleep problems, urinary incontinence, and decline in ability to do normal daily activities compared to those who did not go outside daily.

In a national survey more than one third of adults 60 years and older reported that they exercise every day. For many older adults, high activity levels correspond to a positive perspective on life. Those who exercise daily are much more likely than those who never exercise to say the past year of their life has been better than normal (28%) rather than worse (15%).

Older adults with hypertension participated in a three-day cognitive behavior therapy program in a South Korean Forest. Participants walked, rested and meditated in the forest. Compared to a control group, these participants showed a significant decrease in cortisol levels (a stress indicator) and improvement in quality of life measures.

Older adults in a retirement community who routinely spent more than 30 minutes in outdoor physical activities were less likely to report depressive symptoms and fear of falling.

Gardeners report better health status, improved hand and body strength and flexibility, increased physical functioning, decreased bodily pain, and reduced blood pressure (Wolf & Housley, 2018).

The above conclusions and some referenced studies can lead to the conclusion that outdoor activities have many health benefits for the elderly. For example, older people who are outdoors in a good environment live longer. Suffering from musculoskeletal pain, sleep problems, urinary incontinence, and reduced ability to perform normal daily activities are significantly reduced. Exercise helps maintain good physical functioning and have a positive outlook on life. Outdoor

activity can lead to a decrease in cortisol levels (a stress indicator) and improvement in quality-of-life measures. Older adults who are outdoors more often experienced less depression and fear of falling and have improved hand and body flexibility.

2.1.2. Mental Health

Outdoor activity can reduce emotional tension, volatility, and depression in older adults. Wolf and Housley (2018) searched for some conclusions and results about the mental health benefits of outdoor activities for older adults. Here are some of the conclusions they came up with:

> Measures of people's responses before and after entering an urban green space revealed that both the amount of time spent in the green area and frequency of visits correlated with feelings of mental restoration. Staying an extra 30 minutes increased the restorative effect, and if someone entered with a high stress level their improvement was more dramatic.
>
> Regular physical activity in green spaces provides older people with mental health benefits. Numerous studies have shown extensive links between exercise and positive mood states, decreased likelihood of depression, lower incidence of stress, and improved cognition throughout the entire life span.
>
> Viewing images of nature on a screen or through a window or being outside in various types of green spaces contributes to stress recovery and cognitive health.
>
> Chronic stress (e.g. long-term disease) and stressful events (e.g. death of a spouse) can take a toll on older adult's health. Visiting parks has shown to be a positive way to cope with life stressors (Wolf & Housley, 2018).

As a result of the above investigations and conclusions, it shown that outdoor activities can relieve mental stress and mental recovery in older adults, regular outdoor activities are beneficial

to the mental health of older adults, and exercise is widely associated with positive changes in mood, depression, stress, and cognition.

2.1.3. Social Connection

Outdoor activities can greatly increase socialization and keep seniors from feeling lonely. Research into social interaction has shown that "Approximately one-quarter (24 percent) of community-dwelling Americans aged 65 and older are considered to be socially isolated" (Social Isolation and Loneliness in Older Adults: Opportunities for the Health Care System., 2020). However, other research states "The importance of social interaction in fostering elder health has been supported by many studies. Continued physical and mental activity, and sustained social connections are vital conditions for maintaining a healthy life" (Wolf & Housley, 2018, p. 7). Design of outdoor exercise equipment can encourage older adults to participate in activities together, which will help them to have a healthier social life.

2.2. Human Body Diversity

In *Body Space*, the Third Edition, Haslegrave (2006) states:

> The sizes, shapes and strengths of human beings are very often broken down by age and sex when they are tabulated in anthropometric databases. In defining a target user population for anthropometric purposes, we must also take into account ethnicity (and sometimes regional differences within the relatively homogenous population of a country), social class and occupation (Haslegrave, 2006, p. 55).

The diversity of the human body must be considered holistically in industrial design, not limited to age and gender, but also including ethnicity, social class, occupation and possibly geographical differences. Industrial designers need to recognize the plurality of user groups to

ensure that products are designed to meet the needs and preferences of different groups. Cultural sensitivities and the influence of social factors need to be taken into account, as well as an awareness of the geographical differences that may exist within countries. By combining these factors, designers are able to create more inclusive and practical products that enhance the user experience.

"According to the best information available at the time of writing (supported by evidence and as set out in Guinness World Records 2004), the shortest living adult man in the twentieth century was 570 mm tall, and the tallest was 2720 mm" (Haslegrave, 2006, p. 56). This quote shows the extreme variations in body size during the 20th century, from a minimum of 570 mm to 2720 mm. Designers are faced with the challenge of extreme sizes, and industrial designers were reminded of the need to take into account the wide range of variations in body size. Designers need to consider how to create products that are both ergonomic and responsive to the needs of the user to ensure that the design is practical and adaptable.

2.2.1. Gender Difference

> Are the anthropometric differences between men and woman attributable to underlying biological (i.e., genetic and physiological) differences or to cultural differences in upbringing and lifestyle? We can be fairly sure that sex differences in stature and related body dimensions and most differences in bodily proportions are almost entirely biological in their origin, although there may be a small overlay of differences attributable to lifestyle, etc (Haslegrave, 2006, p. 56).

In this passage the author explores whether the differences in body size stem from biological differences or cultural differences in lifestyle habits. The author suggests that it is primarily a biological origin difference, with a small portion that may be influenced by lifestyle. For industrial

designers, we need a deeper understanding of the biological differences between men and women in terms of body proportions, bone structure and muscle distribution in product design.

Of course, we also need to take into account the changes that occur in the bodies of the small group of people as a result of cultural and environmental factors. By balancing these two aspects, designers can create more inclusive products.

"Obviously, any investigation of sex differences will founder if the samples of man and women who are studied are not truly comparable" (Haslegrave, 2006, p. 58). Based on this information, I believe that the widest range of human data should be selected as the basis of design, and that products should be adapted to the majority of the population rather than to a subset of the population. There may be differences in body size between genders. Therefore, when designing a product, it is important to consider the differences in body size to ensure that the product is suitable for the majority of the population in terms of size, shape and function. There is also a need to avoid basing product design on gender stereotypes. Design should not impose stereotypes or limit user choice.

2.2.1.1. Variation in Body Proportions

> In general, the lengths of the upper and lower limbs are proportionally as well as absolutely greater in men. Thus the ratio of sitting height to stature (sometimes called 'sitting height index' and used as an index of relative trunk length) will be greater in women than in men. The only limb dimension that is proportionally greater in women is buttock-knee length, due to differences in the forms of the male and female buttock. There is no difference between men and women in the proportional values of either head length or head breadth (Haslegrave, 2006, p. 58).

From this passage, we can derive the length and width of the head in males and females, the ratio of the length of the upper and lower limbs, the ratio of sitting height to height, and the length of the buttock-knee. Those conclusions are discussed below.

Upper and lower limb lengths of males and females differ in both absolute and relative senses. In industrial design, products need to be considered in terms of size and proportion. The size and proportions of a product need to be matched to people with different gender body differences to ensure that the product is adapted to a wide range of users. In this regard, industrial designers need to consider whether the product needs to be adjustable or whether the product needs to be of different sizes to accommodate people with different gender body differences.

Women have a greater sitting height-to-height ratio and greater buttock-knee length than men. This needs to be taken into account when designing products that are related to the human body's sitting posture, such as chairs and tables. Since the width of women's hips and the length from the hips to the knees are greater than men's, the data on women's hips may be more persuasive and practical when designing chairs.

There are no significant proportional differences in head length and width between men and women. Therefore, gender differences are not a major consideration when designing headgear or products that need to take headroom into account. So, in the variation of body proportions, the issue we need to pay attention to is the difference between the length of the upper and lower limbs of men and women, the ratio of sitting height, and the length of women's hips to knee, to ensure that the size and proportions of the product are adapted to people with different gender body differences.

2.2.1.2. Variation in Strength

> The strength of the muscle is directly proportional to the effective cross-sectional area of its contractile tissue. The cross-sectional area of a muscle must be closely related to the bulk that is visible to the casual observer or can be measured with a tape. Ikai and Fukuyama (1968), using a sophisticated ultrasound measurement of a cross-sectional area, found strength to be approximately 64 N per cm square of muscle tissue, which was independent both of sex and of age from 12 upward. Trained judo men had the same strength per unit area as untrained people. In general then, it is the quantity not the quality of muscle that counts, at least in strength measurements of short duration (Haslegrave, 2006, p. 61).

From this passage we learn that the amount of muscle strength is independent of gender, it is proportional to the cross-sectional area of the muscle. All people over the age of 12 have a force per square centimeter of muscle tissue of about 64 N. Men trained in judo have the same muscle strength per unit area as untrained men. However, the study only focused on short-term strength and did not do a study on muscle fatigue, so there is no data on this.

However, we industrial designers need to consider muscle fatigue as a factor. We also need to take into account that for other reasons some people's muscle cross-sectional area becomes smaller, leading to a decrease in muscle strength, which affects athleticism and flexibility.

> It is widely accepted that the secondary sex difference of fat distribution and muscle bulk result from the relative concentrations of the sex hormones-androgens in the male and estrogens and progestogens in the female. Testosterone, the most important of the androgens, is produced in large quantities in the testes but also in very small quantities in the ovaries. (The level of testosterone in the blood plasma of men is 20 to 30 times that of women.) In response to given training programmed,

> men show a faster and greater increase in strength than women; this difference is generally attributed to the effects of testosterone (Haslegrave, 2006, p. 61)

In the article it can be seen that there are studies that show that gender differences lead to hormonal differences, hormonal differences affect strength gains, and that men will have an easier time and gain more strength than women with the same training program.

But there are also women who have equally toned muscles. If you compare their muscle strength to the average man, it is possible that women with toned muscles will have more strength. In industrial design we need to be adaptive, for example in outdoor equipment, which needs to be more flexible to accommodate different groups of users. It should not be designed only for people with high strength or low strength but should be compatible with all people who will participate in outdoor activities.

2.2.2. Ethnic Difference

In *Body Space*, it is mentioned that ethnicity leads to body differences. Negroid, Caucasoid, and Mongoloid divisions appear in the article. Because the ethnicity is different, their physical characteristics are also different. The article lists two characteristics, one is Oversize, and the other is Bodily proportions. The author believes that the biggest typical feature is Bodily Proportions because humans are mainly divided into tall people and short people. In terms of male body proportions, Black Africans have longer lower limb proportions than Europeans. Countries or regions in eastern Asia have relatively shorter lower limbs. This difference in the shortness of the lower limbs is most pronounced among the Japanese. The proportion of Chinese and Koreans with short lower limbs is relatively small. Thais and Vietnamese have the lowest proportions of short lower limbs, and so on.

"In practical terms it has to be emphasized that the anthropometric difference between many ethnic group are sufficiently great that a product or item of equipment designed for one group will be unsuitable for another" (Haslegrave, 2006, p. 65). Haslelgrave's point is that anthropometry is one of the very important considerations in industrial design. While she is correct, different physical characteristics due to ethnicity is not something industrial designers need to consider. What industrial designers need to understand are aspects such as human size, proportions, and range of motion, without making distinctions based on ethnicity. I think industrial designers need to consider individual differences and general human body characteristics, rather than single ethnic characteristics. Within the same ethnic group, the differences between individuals may be greater than the differences between ethnic groups. So individual differences rather than differences in ethnic characteristics are more pronounced. Haslegrave (2006) also mentioned that human body proportions are affected to a certain extent by genetic and environmental factors.

However, industrial designers may need to understand and consider the cultural differences and living habits of different racial or ethnic groups to ensure product suitability and acceptability.

2.2.3 Growth and Development

Industrial designers need to pay attention to human growth and development, which involves many aspects, including physiological, psychological, social and cognitive.

> However, the adult condition is by no means stationary. Our bodily Proportions are modified by our lifestyles and the inevitable processes of ageing. The anthropometry who wishes to chart this course (or part of it) may be tempted to do so by a *cross-sectional study* in which several samples of individuals, representative of different age bands, are measured at the same time. (A cross sectional age-band

> sample is known as a ‘cohort’.) However, data gathered by this means have certain limitations. In the case of children, only a very crude estimate can be obtained of the rate at which changes are taking place. Furthermore, Our differences will be confounded by the effects it is necessary to conduct *longitudinal studies* in which a sample of people are followed over an extended period of time. (Pheasant & Haslegrave, 2006, p. 66)

It can be seen from this article that our body proportions will change due to our lifestyle and the inevitable aging process, and some data are estimated and not accurate enough. Therefore, industrial designers cannot design products based entirely on data. They should have a value range to ensure that the product can be applied to more people.

2.2.4. Secular Trends

What are secular trends? The field of industrial design can be understood as the direction of long-term changes in product design and development. Changes in the human body are the main factor leading to changes in product design, and changes in anthropometric data are also secular trends.

Secular trends in human body measurements vary somewhat from those in developing countries to those in Europe and North America. Human body size is still increasing slightly in economically developed countries. "More recent studies indicate that there may still be a slightly increasing secular trend in economically developed countries, although less than the 10 mm Per decade of the earlier part of the 20th century" (Haslegrave, 2006, p. 74). Due to factors such as war and economic downturns, secular trends in human body size in many developing countries have changed later than in European and North American countries. "In many other countries, of course, and particularly in some rapidly developing countries, a secular increase begun much later than in

North America and Europe is continuing" (Hauspie, et al., 1996, p.45). The United States is one of the most ethnically and culturally diverse countries in the world. According to a report on the number of legal immigrants released by the US Immigration Service (2022), there were approximately 45 million from 1850 to 2022, accounting for about 45% of the native American population. As American society ages, many of those individuals will have very different body measurements. Therefore, inclusive design will be the future trend of development.

2.3. Aging

With the development of medical technology, people all over the world are living longer and longer. So what age is considered old? WHO (2022) points out that people aged 60 years and above, saying, "By 2030, 1 in 6 people in the world will be aged 60 years or over. At this time the share of the population aged 60 years and over will increase from 1 billion in 2020 to 1.4 billion. By 2050, the world's population of people aged 60 years and older will double (2.1 billion). The number of persons aged 80 years or older is expected to triple between 2020 and 2050 to reach 426 million." However, American medicine considers persons aged 65 and above to be elderly. “Traditionally, the “elderly” are considered to be those persons aged 65 and older” (*The Elderly Population*, 1990). The Social Security Act stipulates that the minimum retirement age for receiving full retirement benefits is 65 years old. So, these organizations define people aged 65 and above as the elderly. From a biological perspective, “aging results from the impact of the accumulation of a wide variety of molecular and cellular damage over time” (*Ageing and Health*, 2022). Aging leads to a decline in human physical and mental abilities.

> Beyond the middle years of life, most of us will tend to suffer from a steady diminution in our functional capacities, due partly to the ageing process as such and

partly to the effects of previous disease or injury from which recovery has been incomplete (Haslegrave, 2006, p. 80).

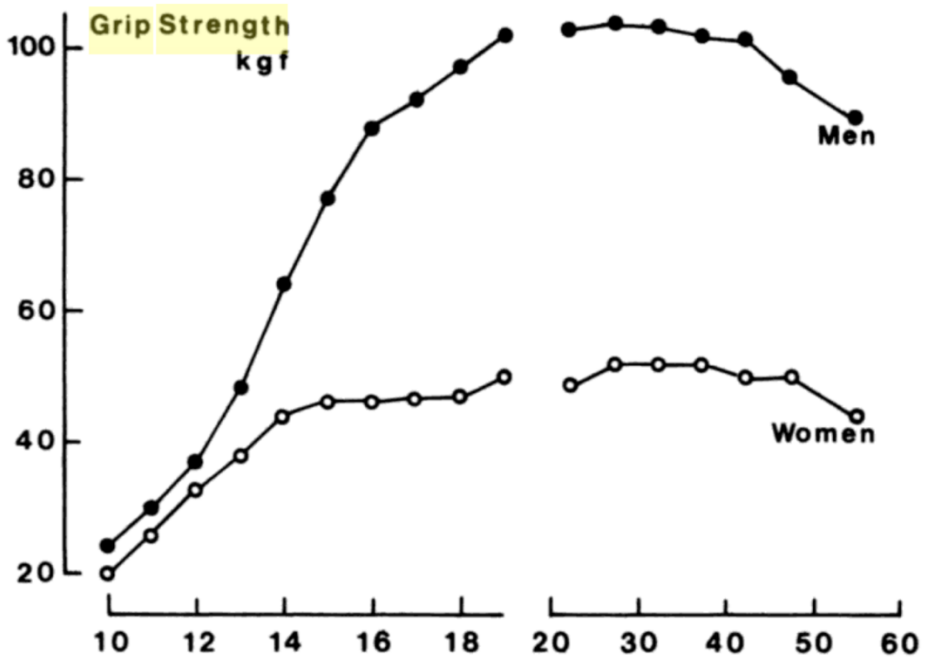


Figure 1: *(*Effects of Age and Sex on Grip Strength*., 1977)*

As shown in the figure, handgrip strength changes with age. The strength decreases significantly around the age of 47. When people become 65 and older, their

> Hand strength is reduced about 16-40%, arm and leg strength is reduced about 50%, the air intake is reduced about 35%, most body breadth decreases with increasing age, nose and ears increase in width and length, weight can increase 4.4 lb (2kg) every 10 years (Henry, 2002, p 33).

Also, most older people will develop chronic conditions,

> More than four of five older persons have at least one chronic condition, and many have several, although these conditions do not necessarily limit significant daily activities. The most prevalent chronic conditions (expressed in terms of

morbidity from these conditions) in the elderly population include arthritis, hypertension, hearing impairments, and heart conditions. Older women experience chronic conditions (such as arthritis and osteoporosis) more frequently than men (*The Elderly Population*, 1990).

At the same time, the number of disabilities increases significantly with age. As shown in Figure 2, the prevalence of disability among those over 60 years of age is on the rise.

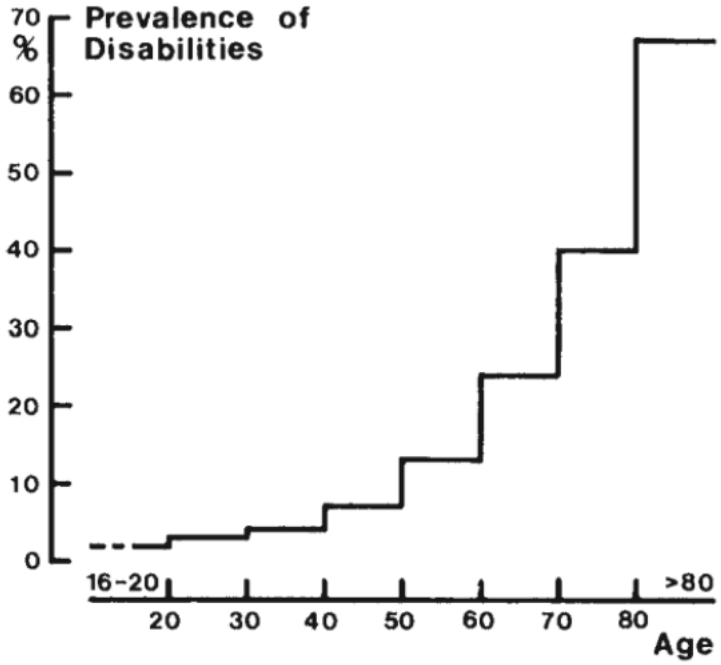


Figure 2: *(*Prevalence of Disabilities in Different Age Groups*, 1988)*

For the process of human aging, it is not only the decline in strength and disability, but also skin problems, hearing loss, and visual decline (cataracts, presbyopia) among the physical changes. "The age changes beyond 50 years of age which seem to be most important for the design of products are those in anthropometric dimensions, walking velocity and step length, forces, fine and gross psychomotor control, hearing and vision" (Haslegrave, 2006, pp. 80, 82). There are also psychological changes such as depression, anxiety, mood swings, and susceptibility to suspicion.

“Common conditions in older age include hearing loss, cataracts and refractive errors, back and neck pain and osteoarthritis, chronic obstructive pulmonary disease, diabetes, depression and dementia” (*Ageing and Health*, 2022).

2.3.1. Aging Changes in the Senses

As age increases, people's bodies will undergo significant changes. Vision and hearing begin to decline:

> The eye focuses more slowly with aging. Moreover, the ability to perceive color diminishes with age because of the yellowing of the lens in the eye. Disability glare doubles with aging. Older people need large visual details. Increase illumination by about 20%. In hearing, high-frequency sounds are lost with aging (Henry, 2002, p. 33).

In addition, skin problems develop: “With aging, the outer skin layer (epidermis) thins, even though the number of cell layers remains unchanged” (*Aging Changes in Skin*, 2022). Joints become stiff and less flexible, muscles atrophy, and contraction ability become poorer, making the elderly's movements worse, slower, and more likely to be restricted. (*Aging Changes in the Bones-Muscles-Joints*, 2024)

2.3.1.1. The Skin

Through research, we know that human skin is divided into the epidermis, dermis, and subcutaneous tissue. The epidermis serves to protect the layers below it from the environment. The dermis gives the skin strength, support, and allows the body to feel pressure, pain, and temperature. The subcutaneous tissue anchors the skin to the fascia and is composed primarily of fat cells. A

person's skin changes with age and the effects of a number of external factors. (*Anatomy and Physiology of Ageing 11: The Skin*, 2017)

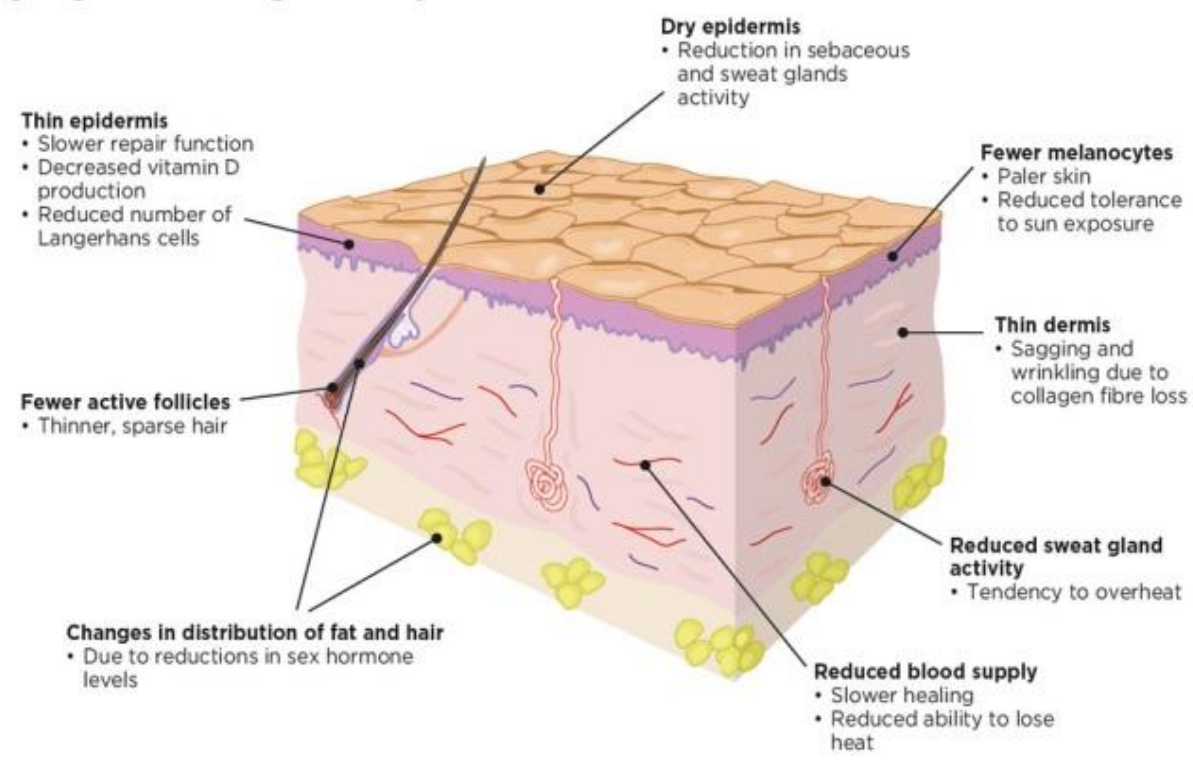


Figure 3: (Lamb, 2017)

The dermis contains mainly capillaries and skin cells, with the key cells being fibroblasts and mast cells. With age, dermal volume decreases, dermal thickness decreases by about 20%, mast cell numbers decrease by 50%, and blood flow decreases by 60%. Collagen content also decreases with it. Skin strength and elasticity decrease. Subcutaneous tissue consists mainly of fat cells. As we age, the subcutaneous tissue begins to lose fat and the risk of skin injury increases. The skin becomes harder, thinner, less taut, less elastic and more fragile. Haptic perception decreases, e.g. hand touch, pressure, vibration, cold and heat become less perceptible (*Anatomy and Physiology of Ageing 11: The Skin*, 2017). Also “Aging skin repairs itself more slowly than younger skin. Wound healing may be up to 4 times slower” (*Aging Changes in Skin*, 2022).

In summary, older people's sense of touch can become dulled. Improperly designed outdoor products can cause physical injuries to older people, thus increasing their internal fear and reluctance to go out and socialize, which causes physical and mental health disorders in the elderly. In addition, due to the reduced sensitivity of the elderly, designers need to consider comfortable, safe, non-slip and other materials when designing outdoor products.

2.3.1.2. The Vision

As we age, vision begins to deteriorate. In daily life, there are external factors that can cause damage to the eyes, such as sunlight, chemicals, polluted rainwater, chlorine in swimming pool water, and sand and dust in the wind. Eye diseases become common with age, with presbyopia and cataracts being the most common. Some retinal diseases are more likely to occur in old age, such as macular degeneration, diabetic retinopathy (if diabetic) and retinal detachment. The muscles of the eye gradually weaken, the pupil becomes smaller, and the response to light becomes delayed. The number of nerve cells decreases depth perception is impaired, and judging distance becomes more difficult (Garrity, 2022). Color perception changes and older adults may have difficulty reading black letters or blue letters printed on a blue background (Stefanacci, 2022).

> Reduced peripheral vision (side vision) is common in older people. This can limit your activity and ability to interact with others. Weakened eye muscles may prevent you from moving your eyes in all directions. It may be hard to look upward (*Aging Change in the Senses, Vision*, 2022).

Therefore, in summary, designers should avoid using colors indiscriminately when designing outdoor products for the elderly. Signs need to be enlarged to make them easier to read and avoid being too high. Rounded or curved corners should be used as much as possible to avoid accidental injury.

2.3.1.3 The Hearing

"About one in three people in the U.S. between the ages of 65 and 74 has hearing loss. Nearly half of those older than 75 have difficulty hearing." (*Age-Related Hearing Loss Presbycusis*, 2021) Hearing changes as people age, with or without exposure to loud noises. For example, it becomes more difficult to hear high-pitched sounds. This is age-related hearing loss (age-related deafness).

> Older people who can't hear well may become depressed or withdrawn from others because they feel frustrated or embarrassed about not understanding what is being said. Sometimes, older people are mistakenly thought to be confused, unresponsive, or uncooperative because they don't hear well. These circumstances can lead to social isolation and loneliness. Hearing loss, even small amounts, is also linked to an increased risk for falls (*Hearing Loss: A Common Problem for Older Adults*, 2023).

Studies have shown that older people are more likely to hear lower pitched sounds. (Stefanacci, 2022)

From the above survey, when designing outdoor products for the elderly, can industrial designers consider creating low-pitched sounds to be used as communication signals? In the case of hearing loss, falls also come along with it, and how to effectively prevent falls among the elderly is also a factor that designers need to focus on.

2.3.2. Aging in the Musculoskeletal System

Musculoskeletal aging is a major cause of mobility or disability in older adults. Muscle deterioration results in an inability to move bones, limiting mobility and flexibility.

> Approximately 1.71 billion people have musculoskeletal conditions worldwide. Also, it's been the leading contributor to disability worldwide. Musculoskeletal conditions significantly limit mobility and dexterity. Because of population growth and ageing, the number of people living with musculoskeletal conditions and associated functional limitations, is rapidly increasing. (*Musculoskeletal Health*, 2022)

What is the Musculoskeletal System? Muscles and bones provide the body with form, stability, and mobility, and the muscular and skeletal systems undergo decline as humans age, with muscles atrophying and bones becoming weak and lax.

> The musculoskeletal system provides form, stability, and movement to the human body. It consists of the body's bones (which make up the skeleton), muscles, tendons, ligaments, joints, cartilage, and other connective tissue. The term "connective tissue" is used to describe the tissue that supports and binds tissues and organs together. Its chief components are collagen and elastic fibers, which are composed of different proteins. The musculoskeletal system undergoes many changes as people age (Alexandra, 2022).

In the elderly, muscles atrophy and become stiff and prone to strain, and bones become loose and brittle. That is why it is more important for older people to exercise to prevent muscle atrophy and osteoporosis.

Joints are lined with cartilage, synovium, and joint fluid to cushion friction between bones, and over time cartilage, synovium, and joint fluid are consumed and lost to friction.

> In a joint, bones do not directly contact each other. Instead, they are cushioned by cartilage in the joint, synovial membranes around the joint, and fluid. Changes

in the muscles, joints, and bones affect the posture and walk, and lead to weakness and slowed movement (Brodkey, 2022a).

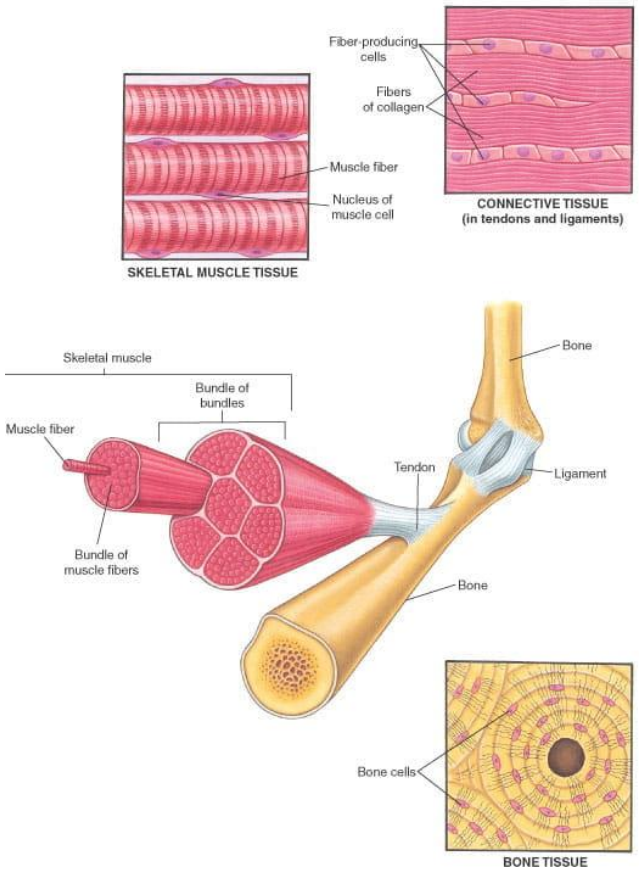


Figure 4: *(*Muscles and Other Tissues of the Musculoskeletal System*, 2022)*

As people age, the density of their bones begins to decrease, the middle part of the body (the torso) becomes shorter, and the intervertebral discs gradually lose fluid and become thinner. Height decreases slightly. The long bones of the arms and legs become more brittle, but length does not change. Joints are affected by changes in cartilage and connective tissue, becoming stiffer and less flexible. Minerals may be deposited in and around certain joints (calcification), which is more common around the shoulders. As we age, the connective tissues within the ligaments and tendons become harder and weaker, the joints become stiffer and less flexible, and these changes limit the range of motion of the joints. Aging results in the beginning of muscle loss, with a gradual

decrease in the amount of muscle tissue as well as the number and size of muscle fibers, and less muscle tone and contraction. Loss of muscle strength increases stress on certain joints, which may make a person more susceptible to arthritis or falls. (Brodkey, 2022a)

Joint damage can lead to inflammation, pain, stiffness, and deformity. Joint changes affect almost all older adults. Movement slows down and may be limited in range of motion. Gait becomes slower and shorter and arm swing is reduced, which can lead to falls and increased risk of injury due to altered gait, instability, and loss of balance. Inability to fully bend or straighten fingers, etc. Issues such as brittle bones, joint problems and loss of muscle mass are more common in older people.

Figure 5: *(*Multiple Boutonniere Deformities of the Fingers and Thumbs in This Person with Advanced Rheumatoid Arthritis*., 2005)*

2.3.3. Psychological effects of aging

As time passes, loved ones leave, and loved ones pass away, seniors begin to become lonely. Some studies have linked loneliness to high rates of depression. Aging affects people with mental health issues.

> The vast majority of elderly (95 percent) live in the community. Of this group, 54 percent live with a spouse, almost 30 percent live alone, and the remaining 16 percent share a home with children, other relatives, or friends. Consistent with widowhood, the percentage of elderly living alone increases with age. Approximately one-quarter (24 percent) of community-dwelling Americans aged 65 and older are considered to be socially isolated (*The Elderly Population*, 1990).

"Everyone needs social connections to survive and thrive. But as people age, they often find themselves spending more time alone. Studies show that loneliness and social isolation are associated with higher rates of depression" (*Social isolation and depression in older adults*, 2021).

Older people need to socialize to avoid isolation and reduce mental health problems.

2.3.3.1. Depression

What is the Depression? "Depression is a true and treatable medical condition, not a normal part of aging. However older adults are at an increased risk for experiencing depression" (*Depression is Not a Normal Part of Growing Older*, 2022). Also, older people are at a higher risk of depression than younger people are at risk.

> Depression is the psychiatric illness that occurs most commonly in old age; it is more prevalent than all forms of dementia and psychosis (Frengley, 1987). Symptoms of depression have been described in as many as 15 percent of community residents (*The Elderly Population*, 1990).

Some studies have shown that genetics, stress, sleep problems, loneliness, lack of exercise and physical activity, and functional limitations that do not allow for activities of daily living may contribute to depression in older adults. Although depression cannot be prevented, maintaining a healthy lifestyle can have long-term mental health benefits. Examples include being physically active and maintaining a healthy, balanced diet. This may help avoid illnesses that can lead to disability or depression. Some diets - including the low-sodium DASH diet - have been shown to reduce the risk of depression. Elderly people should also keep in touch with friends and family and Participate in activities you enjoy. (*Social Isolation and Depression in Older Adults*, 2021)

2.3.3.2. Dementia

"Of those at least 65 years of age, there were an estimated 5.0 million adults with dementia in 2014 and projected to be nearly 14 million by 2060" (*Depression is Not a Normal Part of Growing Older*, 2022). Dementia is not a specific disease but rather a general term for the impaired ability to remember, think, or make decisions that interfere with everyday activities. People with dementia have problems with: Memory, Attention, Communication, Reasoning, Judgment, and Problem Solving, and visual perception beyond typical age-related changes in vision.

Dementia is also a cause of cognitive impairment. The most common types of dementia are Alzheimer's disease, vascular dementia, Lewy body dementia, frontotemporal lobe dementia, and mixed dementia, with Alzheimer's disease being the most common. Some studies have shown that leading a healthy lifestyle, including regular exercise, healthy eating, and maintaining social contacts, decreases chances of developing chronic diseases and may reduce the number of people with dementia. (*About Dementia*, 2019)

2.3.3.2.1. Alzheimer's

Alzheimer's disease is a brain disorder that slowly destroys memory and thinking skills, and eventually, the ability to carry out the simplest tasks. In most people with Alzheimer's, symptoms first appear later in life. Estimates vary, but experts suggest that more than 6 million Americans, most of them age 65 or older, may have Alzheimer's. Memory problems are typically one of the first signs of cognitive impairment related to Alzheimer's. Some people with memory problems have a condition called mild cognitive impairment (MCI).

Some studies have shown that a nutritious diet, physical activity, social engagement, and mentally stimulating pursuits have all been associated with helping people stay healthy as they age. These factors might also help reduce the risk of cognitive decline and Alzheimer's. (*Alzheimer's Disease Fact Sheet*, 2023)

2.3.4. Elderly with Disabilities

As time passes, older people increase and disabilities become common, society needs to provide equal treatment for people with disabilities. Designers need to consider this segment of the population that suffers from disabilities or has special needs when designing products. "Forty-three million Americans have one or more Physical or mental disabilities, and this number is increasing as the population grows older. Before the ADA, these people were isolated or segregated" (Henry, 2002).

According to the Centers for Disease Control and Prevention (CDC), there are six main types of adult disabilities in the United States: hearing, vision, cognitive, mobility, self-care, and independent living. One in four adults in the United States has at least one of these disabilities.

> Using 2016 Behavioral Risk Factor Surveillance System (BRFSS) data, CDC scientists analyzed the survey responses of those adults 18 years of age and older who had any of the following six types of disabilities: Hearing (serious difficulty

> hearing); Vision (serious difficulty seeing); Cognition (serious difficulty concentrating, remembering, or making decisions); Mobility (serious difficulty walking or climbing stairs); Self-care (difficulty dressing or bathing); or Independent living (difficulty doing errands alone). They found that 1 in 4 adults in the United States, or 61 million people, have at least one of these disabilities. However, this report found disabilities more common among adults 65 years of age and older; approximately 2 in 5 adults in this age group have a disability. (*People with Disabilities and Access to Health Care*, 2020)

CDC's disability survey results show that mobility impairments are the most common impairment, with about one in seven adults having a disability, followed by cognitive impairments, independent living impairments, hearing impairments, visual impairments, and self-perception impairments. Cognitive impairment in older adults is the most common, about one in four.(*People with Disabilities and Access to Health Care*, 2020) As they age, older adults experience changes in upper body dimensions, reduced strength and vision or hearing loss leading to poor balance.

Older persons are at increased risk of falls and injuries due to decreased stability, balance and endurance, as well as diseases such as arthritis and osteoporosis. When mobility is impaired, mobility aids, such as wheelchairs, canes and walkers, are needed to help older persons meet the demands of daily living.

2.3.4.1. Wheelchair

A portion of the population chooses wheelchairs as an assistive device depending on their balance ability, and the following is data on wheelchair users.

> The number of older adults who use wheelchairs had increased significantly from 4.7 per 100 people in 2011 to 7.1 in 2019 (P<.001). There are approximately

3.3 million Americans who use wheelchairs. Older adults are the largest group of consumers of assistive technology such as wheelchairs. In the US, there are an estimated 1 million wheeled mobility device users aged 65 and older, most of whom use manual wheelchairs.3 According to the data published decades ago, the use of wheelchairs among older adults had been increasing over time (Nie et al., 2024).

In the above data, it can be concluded that the number of wheelchair users in the United States is increasing, mainly among the elderly and most of them choose to use manual wheelchairs. As a result of using a wheelchair for activities of daily living, older adults can experience symptoms of shoulder pain. Wheelchair users may do so because of physical limitations, impaired balance, strength limitations and mobility impairments

It has been noted that wheelchair-using and non-wheelchair-using older people do not go out as often, with wheelchair-using older people being much less likely to go out on a regular basis, and that the lower frequency of outdoor activities may be due to their health and functional limitations or to the social environment, where the physical environment, such as the natural elements, buildings, and landscapes, for example, can affect wheelchair mobility.(Nie et al., 2024)

2.3.4.2. Canes

When seniors have minor problems with balance or stability, some weakness in the legs or torso, injuries or pain, canes can help seniors walk comfortably and safely and maintain independent living. (*Canes*, 2020)

People with visual impairment also use canes when they are not the same as older people with balance problems, who use them for exploring the road ahead and the obstacles around them.

2.3.4.3. Walkers

When an older adult's body is unable to maintain balance and stability, but there is sufficient strength in the arms and shoulders, and the older adult needs additional support and stability a walker will provide the older adult with additional support and safety, reducing the amount of force and pain exerted on the joints. Walkers provide moderate protection from forward falls, but walkers do not prevent backward falls. (Judge, 2021)

2.3.5. Exercise they Need

The CDC has recommended the elderly exercise for 150 min per week, and muscle-strengthening exercises twice per week. Also balance training is needed that includes all major muscle groups (legs, hip, back, abdomen, chest, shoulders, and arms) (*CDC*, 2023)

2.4. Others

2.4.1. ADA Standard

The ADA standards are a design standard for accessibility for persons with disabilities adopted by the U.S. Department of Justice in 1991. The guidelines were revised in 2010 and the ADA standard is not only a guideline but also a law. Understanding the ADA Standard Guidelines is an important criterion for designers to consider when designing a building or facility to be accessible to people with disabilities:

> The 2010 Standards set minimum requirements – both scoping and technical – for newly designed and constructed or altered State and local government facilities, public accommodations, and commercial facilities to be readily accessible to and usable by individuals with disabilities (*ADA*, 2010a).

2.4.2. Anthropometry and Ergonomics

Henry Dreyfuss Associates' (1992) published anthropometric data plays an important role and is used in ergonomics, industrial design, clothing design and architectural design. Anthropometry and ergonomics are two closely related disciplines. Anthropometry provides basic data on human dimensions, and ergonomics applies this data to optimize products to increase safety and comfort. Designing equipment for outdoor exercise requires learning and understanding anthropometry and ergonomics to increase safety and comfort while avoiding accidents:

> The large elderly man has lost 5% of his height, compared to when he was 20 years old, because of several factors. The elderly Man no longer has the growth advantage of 0.4 inch (10mm) per decade, and his cartilage has shrunk, mostly throughout the spine. Also, posture among the aged has a more slumped character. The small elderly woman has lost 6% of her height for the same reasons as the elderly man (Henry, 2002).

Like the passage quoted above, we wouldn't know this accurate data if we didn't understand anthropometrics, and without knowing the accurate data it would be impossible to design outdoor exercise equipment for the elderly and disabled elderly.

2.4.3. ASTM Standard

The ASTM standard is intended to promote proper design, manufacture, installation, and operation of unsupervised outdoor fitness equipment for use in outdoor activity areas. The purpose of the standard is to specify requirements for outdoor fitness equipment and its installation, the design of facilities or sites where the product is not installed, and the minimization of the potential for serious injury. The equipment is intended for unsupervised use by persons 13 years of age and older. Learning and understanding this standard can allow design of safer and more comfortable

outdoor exercise equipment for seniors and people with disabilities (*Standard Specification for Unsupervised Public Use Outdoor Fitness Equipment*, 2021).

2.4.4. Outdoor exercise equipment

When examining some of the outdoor sports equipment on the market for the basic investigation, it was found that they do not have a standard size requirement. For example, in the case of the Air Walker, two items have the same function, but their size is not the same. The foot platform and the height of the handrail are not the same.

Figure 6: Single Station Sky Walker (Willy Goat)

Figure 7: Cardio Walker (Practice Sports)

Chapter 3 Guideline

Through research, we have found that aging can lead to problems with the skin, vision, hearing, and skeletal-muscular systems. These problems affect the ability of elderly to engage in outdoor exercise. At the same time, the survey pointed out that outdoor activities are beneficial to the physical and mental health of elderly and elderly with disabilities. The current market for outdoor exercise equipment does not meet the needs of elderly and elderly with disabilities. No standards have been found to measure the suitability of outdoor exercise equipment for elderly and elderly with disabilities. It is important to develop outdoor exercise equipment for the elderly.

Therefore, in this guideline, I categorize elderly into those who use aids, those who do not and elderly with special disabilities. However, both older people who use aids and those who do not will experience a decline in their skin, hearing, and vision as they age. Therefore, I have made a separate list of skin, hearing, and vision problems caused by aging.

In this guideline, because the elderly people have different physical qualities, I have included anthropometrics, ergonomics, ADA guidelines, and ASTM guidelines for outdoor activity equipment. The goal is to be able to develop outdoor activity equipment that is suitable for use by older adults and older adults with disabilities.

3.1. Basic Development of Guideline

According to CDC recommendations, older adults and older adults with disabilities should exercise for a minimum of 150 minutes of moderate-intensity aerobic activity at least twice a week, and muscle- strengthening at least twice a week. These strength exercises should include all major muscle groups (legs, hip, back, abdomen, chest, shoulders, and arms). Older adults need to increase activities that work on balance (e.g., standing on one foot or heel-to-toe walking).

3.1.1. Aerobic Activity

Aerobic exercise has many benefits for older adults, such as improving cardiovascular health, improving sleep, cognitive function, immune function, and bone health, and reducing weight, chronic disease, and fall risk. Aerobic exercises include brisk walking, running, stair climbing, yoga, Pilates, tai chi and so on. Outdoor exercise equipment for aerobic exercise include Exercise Bike, Rowing Machine, Air Walker, Elliptical Cross Trainer, and Air Strider.

Figure 8: Exercise Bike (Gopher Outdoor Gym Exercise Bike)

3.1.2. Muscle- Strengthening

Muscle strengthening, balance and flexibility improvement reduce falls. Muscle strengthening exercises include, lifting heavy weights, yoga, Tai chi and more. Older adults need major muscle group exercise, which includes legs exercise, hip exercise, back exercise, abdomen exercise, chest exercise, shoulders, and arms exercise.

3.1.2.1. Legs Exercise

The quadriceps is a muscle that pulls the tendons on the knee through muscle contraction to straighten the knee and lift the knee to maintain an upright posture, and is definitely used in walking, running and jumping. Therefore, older people need to exercise their quadriceps to reduce the risk of falling.

The leg press specifically emphasizes the quadriceps, glutes, and hips. Leg press equipment avoids the risks associated with squatting with large weights while standing. There are a variety of leg presses on the market; the following figure is a more common design for designers to refer to.

Figure 9: Leg Press (The Park and Facilties Catalog)

3.1.2.2. Hip Exercise

The hip joint is one of the most important joints in the human body, linking the trunk and lower limbs. Walking, running, etc. are not without the support of the hip joint. The flexibility of the hip joint determines the stability of walking and can affect normal bending and squatting and other actions.

The Hip Twister is very useful for older people to develop lower back flexibility and balance; it works primarily on the core muscles and secondarily on the leg muscles and arm muscles. It makes the body more flexible.

Figure 10: Hip Twister (FreshairFitness)

3.1.2.3. Back Exercise

Exercising the back muscles can help seniors improve overall mobility, stability, and independence. Strengthening the back muscles can better help seniors maintain balance, increase spinal stability to maintain mobility, and reduce back pain.

The back extension equipment strengthens the lower erector spinae muscles in the lower back, as well as the gluteal and hamstring muscles. This exercise, done regularly, will also result in improved posture and overall physical stability.

Figure 11: Sit up/Back Extension (Practice Sports)

3.1.2.4. Abdomen Exercise

Declining abdominal muscles can cause older adults to become less athletic, walk unsteadily, and be unable to protect their backs, also increasing the likelihood of low back pain. Exercising the abdominal muscles increases spinal support and stabilizes the core to prevent falls.

Through basic research, there is currently no outdoor sports equipment specifically designed for abdominal exercises because much equipment will mention exercising the core during exercise, and the core includes abdominal muscles. For example, in the picture above, sit up/Back Extension, and Hip Twister, and the Rower pictured below, works the arms, back and core muscles for strength training.

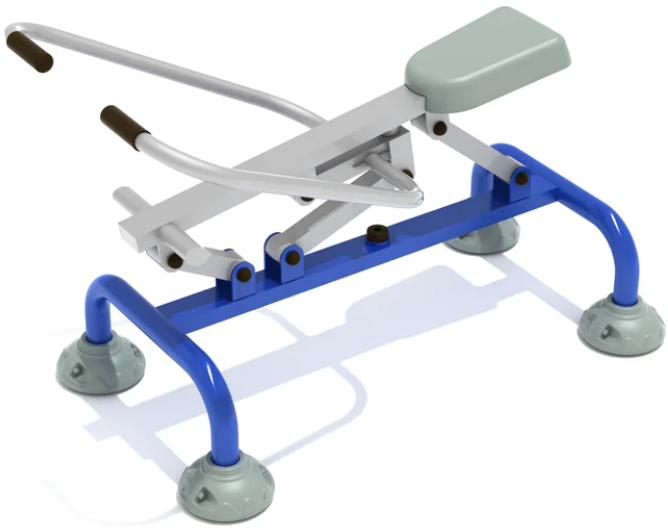


Figure 12: Rower (Willy Goat)

3.1.2.5. Chest Exercise

For older adults, chest exercises can change the mobility and flexibility of the upper chest and shoulders, and increasing chest exercises can simultaneously increase the mobility of the rib cage and help ventilate the lungs.

A Chest Press can help older adults with chest exercises. It supports and promotes overall upper body strength, emphasizing the triceps, pectorals, and deltoids during the pushing motion.

Figure 13: Chest Press (Practice Sports)

3.1.2.6. Shoulders and Arm Exercise

Shoulder and arm exercises increase the range of motion of shoulders, stabilize the scapulae, and improve grip, pushing, and pulling abilities.

Pull-up bars can support many more exercises, including shoulder and arm stretching, improving the grip, and the hanging knee lift which strengthens the abdominal muscles.

Figure 14: Pull-Up Bars (Willy Goat)

The Tai Chi Wheel enhances the strength and elasticity of the shoulder girdle muscle groups, improves the suppleness of the shoulder joint, is suitable for people with stiff shoulder joints, and is conducive to the rehabilitation of shoulder trauma.

Figure 15: Tai Chi Wheel (TRAINER)

3.1.3. Balance

Loss of balance is an inevitable part of the aging process. Aging leads to a decline in balance and coordination in older people, and the loss of good posture and muscle mass leads to

impaired walking and gait, longer reaction times and an increased risk of falls.

Figure 16: Assisted Balance Walk (Action Fit)

3.1.4. Wheelchair User

Regular aerobic exercise and muscle strengthening exercises are equally important for wheelchair users. Cardiovascular physical activity that raises the heart rate is particularly difficult for older people using wheelchairs, and muscle-strengthening exercises can help older people to become more independent in their daily lives, as certain muscles in the upper body may be strained due to the need to push the wheelchair. Examples of outdoor exercise equipment suitable for wheelchair users include the Chest Press, Hand Bike, and Tai Chi wheel. This equipment is for upper limbs.

Figure 17: Hand Bike *(*BackYard Solutions LLC*, n.d.)*

Wheelchair users need to be aware of certain muscle groups when performing muscle strengthening exercises; chest and shoulder muscles are prone to injury when pushing a wheelchair, and back muscles don't get much exercise. Gluteal and leg muscles don't get exercised and begin to atrophy.

3.1.5. Sensory Degeneration

The senses mainly include the "five senses" of the human body, i.e. vision, hearing, taste, touch, and smell. Most of the sensory functions of the elderly decline in the order of vision, hearing, smell, taste, and touch. Only the senses of vision, hearing and touch will be discussed here.

Although the degree and process of individual aging varies a lot, and the physiological functions and social behavioral abilities of each person at this stage are different, physiological aging is an irreversible process, and the trend of overall decline in terms of sensory functions in the elderly is a natural law. With the decline of sensory function, the human body's muscle response ability, visual function, auditory function and pain function will decline. Considering this decline in functionality, designers should consider how to design outdoor exercise equipment to make it more comfortable for the user.

3.1.5.1. Skin

Due to aging, the sense of touch of the elderly will become dull, sensitivity decreases, and the skin becomes thin, easy to break and not easy to recover, so designers should design products to avoid protruding spikes and shear points. And there should be a smooth coating in the place where the skin touches to avoid abrasion.

3.1.5.2. Vision

Designers should avoid using colors indiscriminately when designing outdoor exercise equipment for seniors, for example, avoiding using green, blue, and purple at the same time while increasing contrasting colors. Signs should be enlarged for easy reading, not be placed too high or too low, and should be placed within the visual area. Rounded or curved corners should be used as much as possible to avoid accidental injury.

3.1.5.3. Hearing

Due to aging, it becomes difficult for older people to hear high-frequency tones. Impaired hearing makes older people vulnerable to falls. When designing products, it is important to place handrails within easy reach to prevent sudden falls where there is no place to hold on to. Whenever possible, devices should be designed in a rounded shape to avoid protruding objects from hurting the elderly.

3.1.6. Requirement

Anthropometrics can be used to understand the body data of the elderly, based on which the dimensions of the product can be developed, and ergonomics can make the product comfortable and safer to use.

In this chapter, I distinguish between elderly who do not use aids and elderly who use aids and older people with special disabilities, because it was found that older people who do not use aids do not differ much from the general population in the aging process. Differences occur only in height size, strength and joint range of motion which become smaller due to the intervention of aids, so that older people who use aids have a limited range of motion of the joints of the body and at the same time increase the space of the range of motion of the body. The range of motion of the body joints of the older adults using aids is limited and at the same time the space of the range of motion of the body is enlarged.

The elderly with special disabilities are not discussed due to data and time constraints. However, if there is a need, it is necessary for the designer to make observations, visits and measurements.

3.1.6.1. Elderly without Assistive Devices

In the figure below are the body data for 99%, 1% and averages of the elderly. This data can allow analysis of the size of outdoor exercise equipment needed for the elderly. The data of the upper and lower limbs are analyzed individually and then how to develop the part of the outdoor exercise equipment that will be in contact with the limbs is explained. This will cover the data of the body parts of the elderly people who use the aids. This facilitates industrial designers to get the desired data.

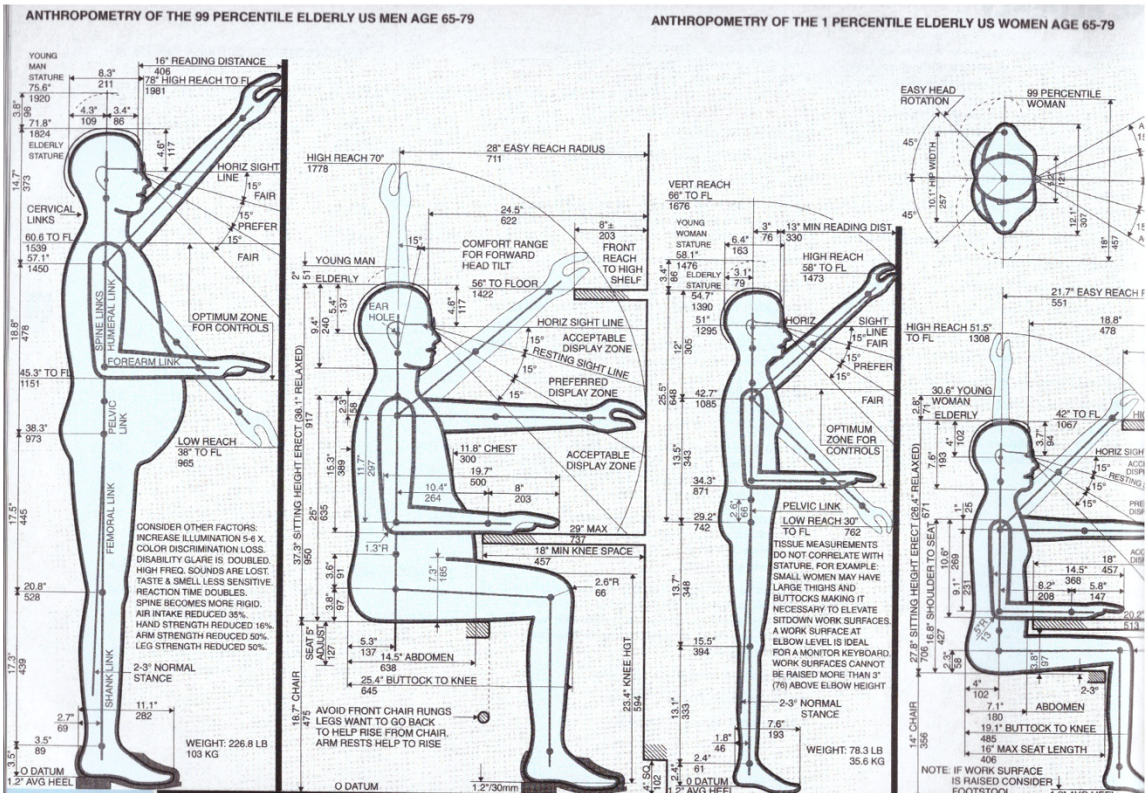


Figure 18: Anthropometry of the 99 Percentile Elderly US Men Age 65-79(Dreyfuss, 2002h)

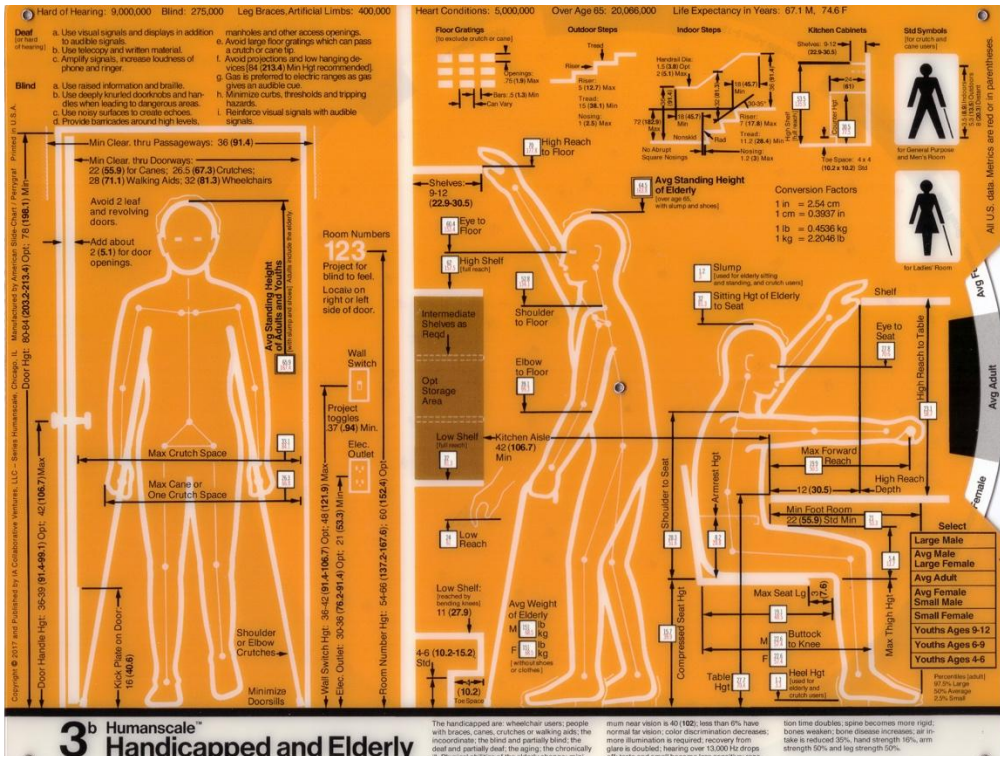


Figure 19: Handicapped and Elderly(Dreyfuss, 2002f)

3.1.6.1.1. Upper Limbs

3.1.6.1.1.1. Handgrip

Older adults can't do outdoor exercise equipment without a handgrip, so it's extremely important to make them comfortable. Therefore, it is important to have hand anthropometrics; the following is Henry Dreyfuss Associates' summarized hand measurement data.

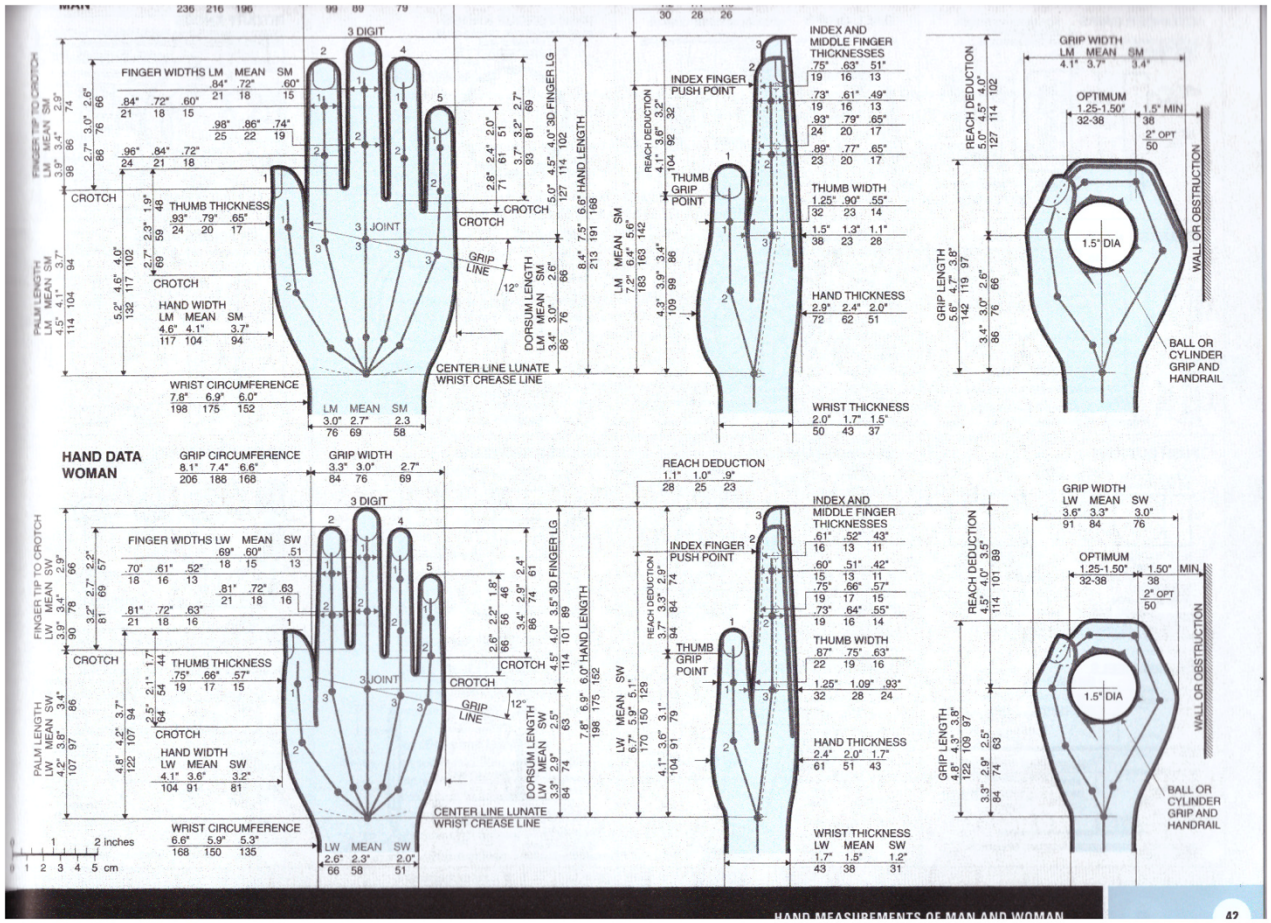


Figure 20: Hand Measurements of Man and Woman(Dreyfuss, 2002e)

In the above data it can be seen the measurements of 1.5 inches for the hand closed size, and the book also gives gripping handles diameter of 0.875-1.25 inches (Henry Dreyfus's Associates, 2002.p.74). This size is suitable for normal hands, but not suitable for the elderly. Due to some of the elderly suffering from arthritis of the hand, the fingers cannot be completely bent or straightened, so the outdoor exercise equipment handgrip size needs to be adjusted. A diameter of 1.25 inches to 2 inches is more appropriate, and in the palm of the hand to increase the support, in the use of more comfort.

In outdoor exercise equipment handgrips should not be square or angular shape but should be round or oval. To avoid accidents, a round or oval shape will minimize injuries. Surface texture

should be added, but not so rough as to be abrasive. If allowed, the handrail should have a soft rubberized material for added comfort and safety.

The distance between the handgrip and other obstacles should be not less than 1.5 inches, but 1.5 inches-3 inches is more appropriate because for some older people who suffer from Parkinson's disease, their hands will involuntarily tremble. Referencing the above picture in hand thickness, the greatest thickness is for 2.9 inch, so in order to avoid hand friction, 3 inches may be more appropriate, and at the same time 3 inches is also a safe space.

3.1.6.1.1.2. Arm Range

The survey shows that aging does not cause bones to become shorter, so the reach of the arm to the front has a smaller range of variation. In Figures 18 and 19, from the anthropometry of the 99% of elderly US men, an easy reach radius is 28 inches. In the standing state the reach radius is 16 inches away from the obstacle in front, the highest reach is 78 inches, and the lowest reach is 38 inches. According to the anthropometry of the 1% of elderly US women, an easy reach radius is 21.7 inches, and in the standing state from the obstacle in front, the highest reach is 78 inches, the lowest reach is 38 inches. For elderly US women, the easy reach radius is 21.7 inches, with a maximum reach of 58 inches and a minimum reach of 30 inches when standing 13 inches from the obstacle in front. For the average older adult (Figure19), the easy reach radius is 23.1 inches, with a maximum reach of 70 inches and a minimum reach of 24 inches when standing 12 inches from the obstacle. They have limited range of motion in their joints due to disease, such that lifting upward begins to become difficult.

Based on anthropometric data, anthropometry of the 99% elderly men, anthropometry of 1% elderly women and the average elderly person, I have compiled a dimension of how far the arms can reach. The easy reach radius is 22 inches. If the time is spent on an outdoor exercise

equipment with a single grip, then the maximum touch height is 58 inches when standing, and if it has multiple grips, maximum touch height should be 58-70 inches. The minimum touch height is 34-38 inches. Outdoor exercise equipment handrail height should measure between 38 to 40 inches, platform to handle.

3.1.6.1.2. Lower Limbs

Understanding lower limb data in the elderly can make exercise on the outdoor equipment be safer, avoiding hazards while increasing comfort in the elderly.

3.1.6.1.2.1. Leg Range

Figure 18 provides the data of leg length of elderly people. Only having the data of leg length is not enough, so designers also need to have the data of leg rotation so that industrial designers in the design of outdoor exercise equipment can avoid more risks. For example, the existing Air Walker does not have a limit, but due to the elderly's flexibility deterioration, the elderly in the use of muscles may experience strain or some other dangers; they are very easy to cause. In Figure 21, there is a range of human leg rotation. Since there is no data on leg rotation for the elderly, I will refer to this chart to define the range of motion of the legs of outdoor exercise equipment for the elderly.

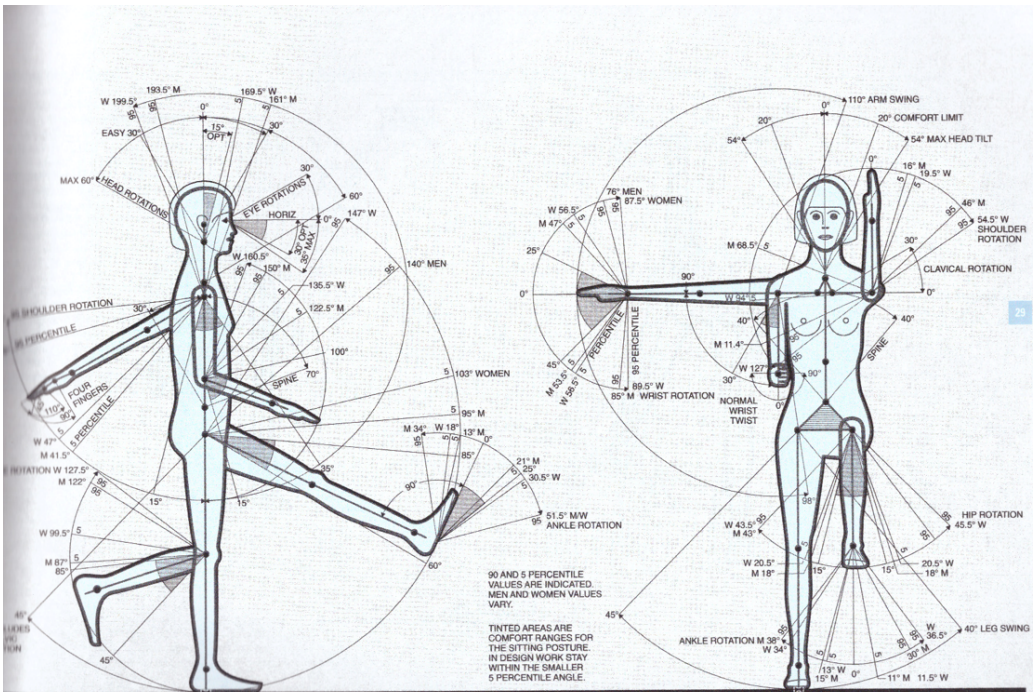


Figure 21: Angle Movements of Body Components(Dreyfuss, 2002a)

Firstly, when making outdoor exercise equipment for seniors, we need to increase the range of restrictions to avoid injuries to the elderly.

In Figure 21 we know that the leg can be lifted 60 degrees forward 45 degrees backward. I will define 45 degrees of forward lift and 30 degrees of backward lift as the range of leg rotation for older adults.

3.1.6.1.2.2. Step

There is some outdoor exercise equipment with protrusions or pedals (e.g., the Air Walker's pedals) that I would categorize as Steps. In Figure 22 we can tell that the Anthropometry of the 99 percentile men's feet is 11.7 inches in length and 4.5 inches in width. Using this measurement as a reference, it should be assumed that this size is already the maximum size that will satisfy everyone (except in special cases). Figure 22 shows the outdoor steps developed by Anthropometry.

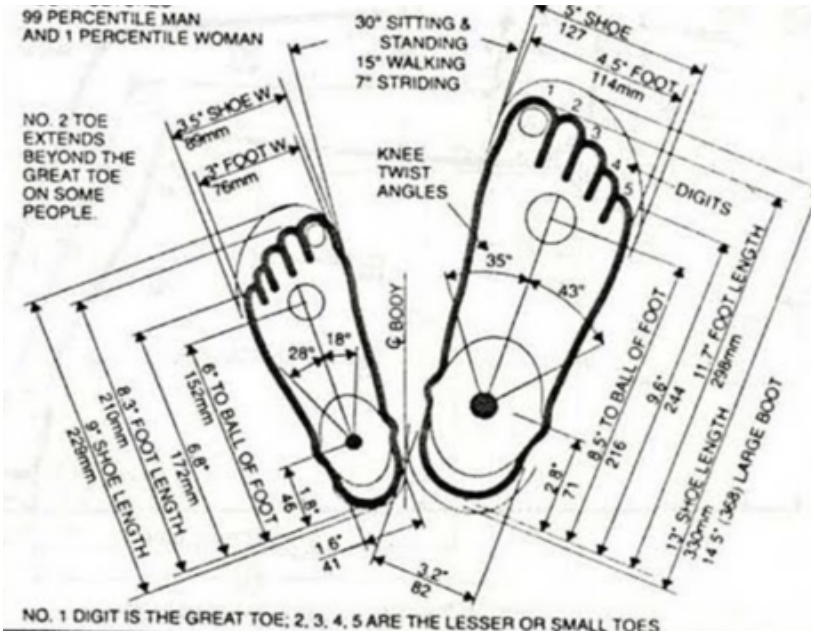


Figure 22:Foot Postures(Dreyfuss, 2002m)

I've set 15 inches as the length and 6 inches as the width for a single pedal area with 1-inch height panels on the area around of the pedal (Figure 23). The side panels should not be sharp and need to be chamfered to avoid injury to the elderly. The two-foot pedal is 15 inches long and 24 inches wide for the pedaling area, with 1-inch height side panels in the area around the pedal (Figure 23). The side panels should not be sharp and should be beveled to avoid injury to the elderly. All pedals should be no more than 5 inches from the floor and have a non-slip feature.

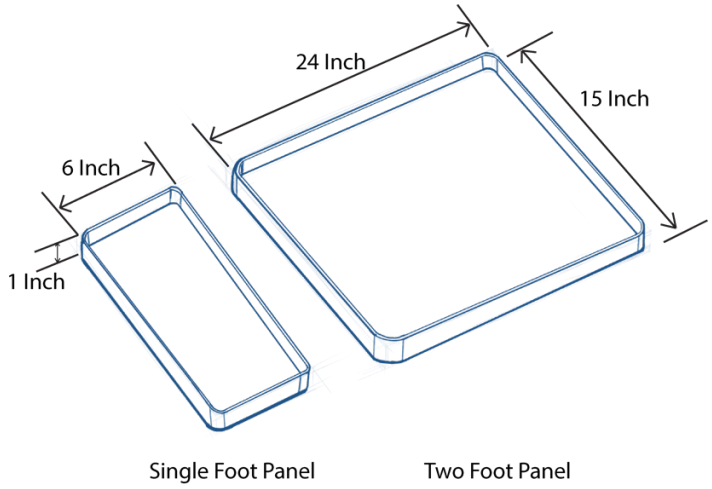


Figure 23:Foot Panel

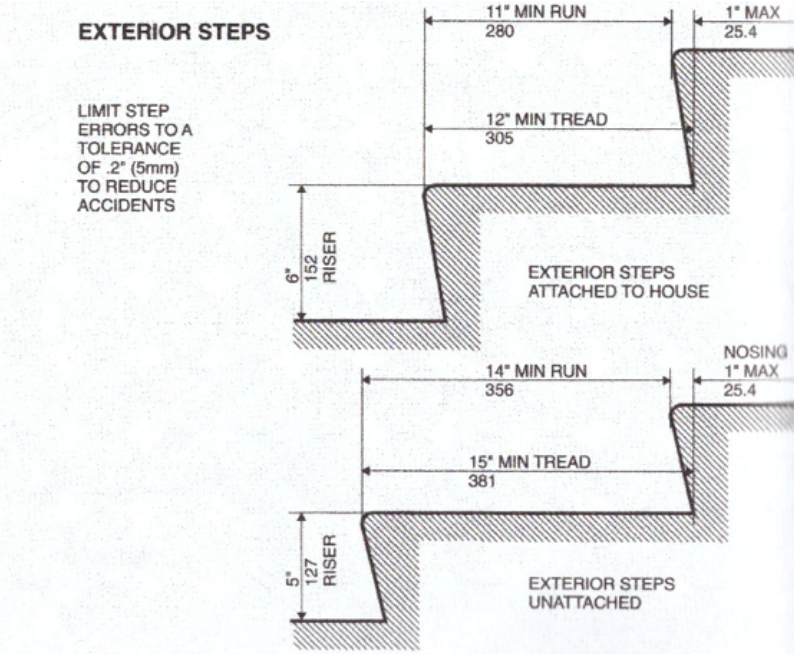


Figure 24:Exterior Steps(Dreyfuss, 2002d)

3.1.6.1.2.3. Seating

In Figures 18 and 19, anthropometry of the 99% elderly men have lower extremity length of 38.3 inches and a seat height of 18.7 inches, and armrest height 9.2 inches. Anthropometry of the 1% elderly women indicates a lower extremity length of 29.2 inches and a seat height of 14 inches, and the armrest height is 7.1 inches. The anthropometry of the average lower limb is approximately 33 inches, the seat height is 15.7 inches, and armrest height is 8.2 inches.

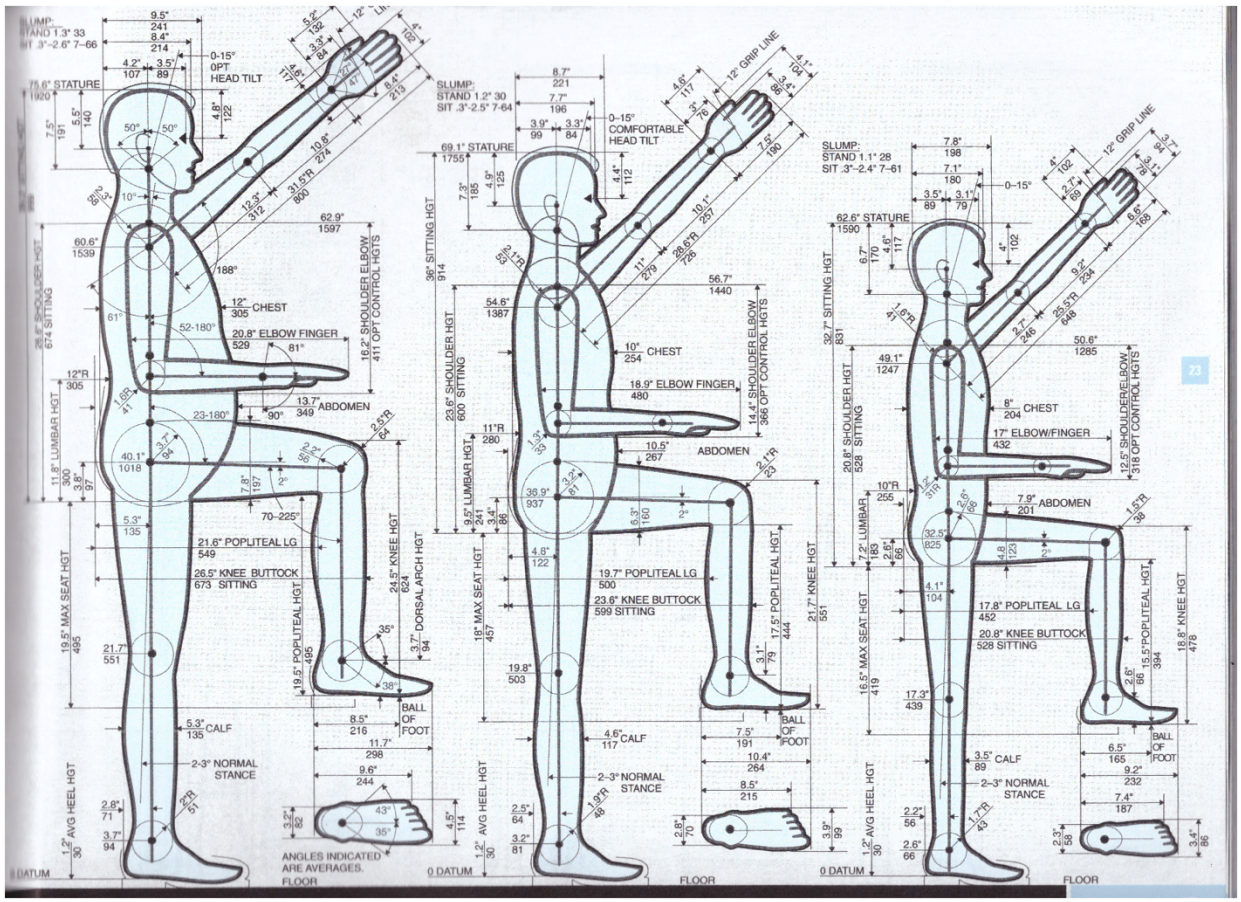


Figure 25: The Measure of Man (Side View)(Dreyfuss, 2002o)

Based on the data, the seat height for outdoor exercise equipment should be between 14 inches to 16 inches, armrest between 7 inches to 8.5 inches, the armrests are diagonally shaped approaching the backrest at 7 inches and the other side at 8.5 inches. These measurements allow for more users to be accommodated. Seat depth should be between 14 and 15 inches. Seat width minimum is 16 inches. Seat backrest should be 12 to 16 inches. Seat and backrest angles between 105 degrees and 110 degrees can be more comfortable. To allow eating, the seat should be horizontal. Seated exercise equipment backrest angles between 90 degrees and 105 degrees.

3.1.6.1.2.1.1. Seated Exercise Equipment

When designing outdoor seated leg exercise equipment (such as a leg press, etc.), designers need to understand not only the data of leg length, but also the degree of leg flexion, the range of motion of the ankle, the overall seated position plus the range of motion of the leg, and other relevant information. The following anthropometric data can be used to help designers create seated exercise equipment that is comfortable and safe for older adults to use.

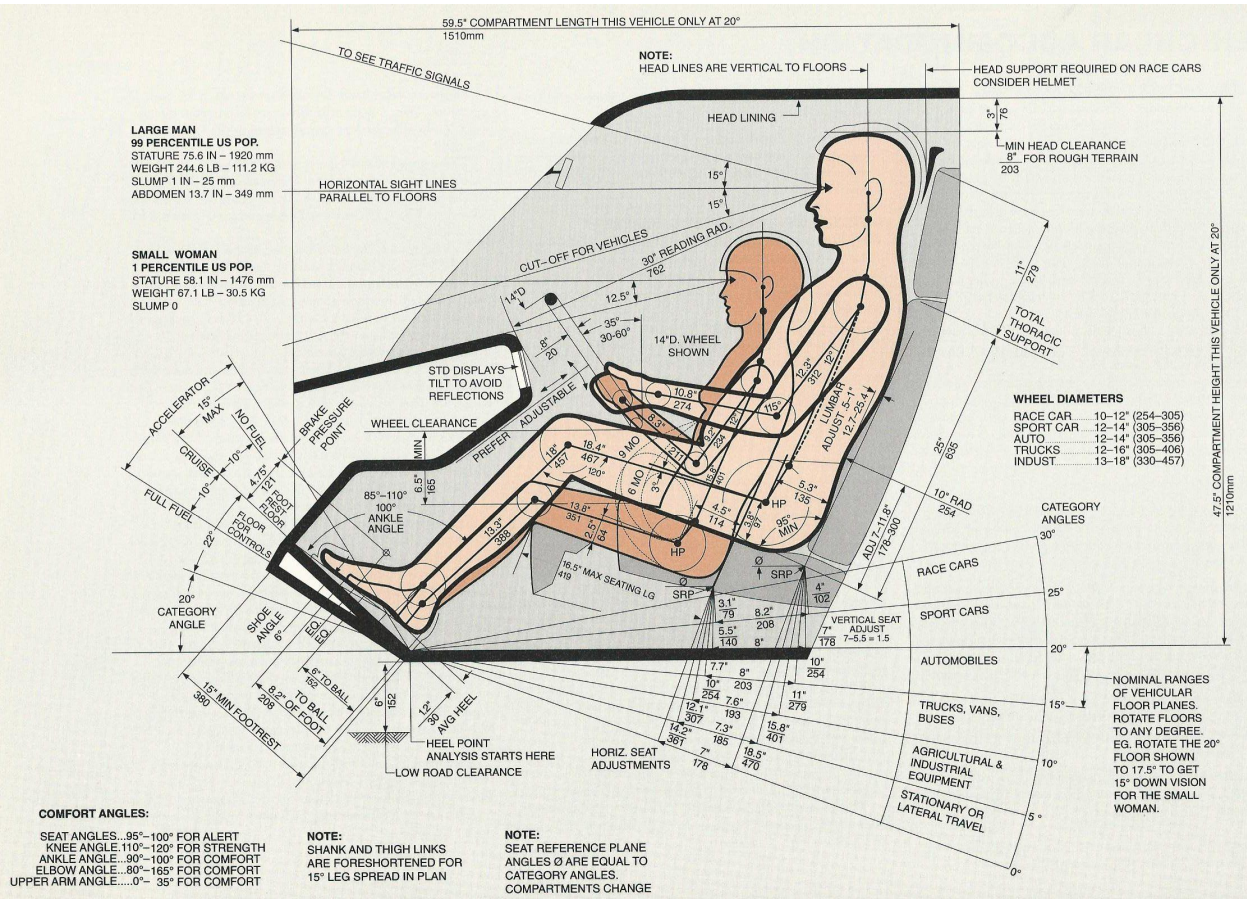


Figure 26:Constant Factors in Vehicle Seating(Dreyfuss, 2002f)

3.1.7. Elderly used assistive devices

As seniors age or for some unforeseen reason, they often require assistive devices to help them live independently. When an older person begins to use an assistive device, it is basically a sign that the assistive device will stay with the older person. Therefore, the design of outdoor

exercise equipment for the elderly needs to take into account the use of assistive devices so the elderly can safely use outdoor exercise equipment and can have a place to put the assistive devices.

First, designers should do research to find relevant information, look for relevant government documents, and check to see if there are any relevant laws and regulations on what is required (e.g., ADA Standards).

Second, they should find data and space requirements for the use of assistive devices by older adults and standardize outdoor exercise equipment based on that data to make it standard and compliant so that older adults can use the equipment more safely and comfortably.

Last, because older adults use assistive devices, designers need to consider where in or around outdoor exercise equipment to place assistive devices to make it more convenient for older adults.

I will put basic data on older adults with disabilities below for reference. Additionally, I will place the ADA standards requirements below and analyze it against anthropometric data.

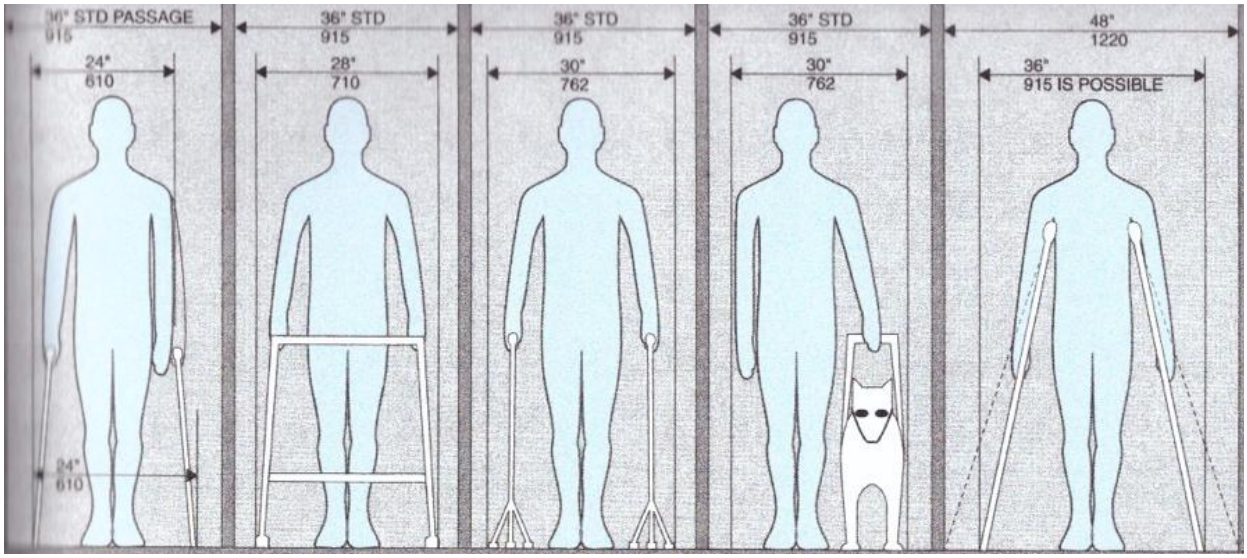


Figure 27: Passageway(Dreyfuss, 2002h)

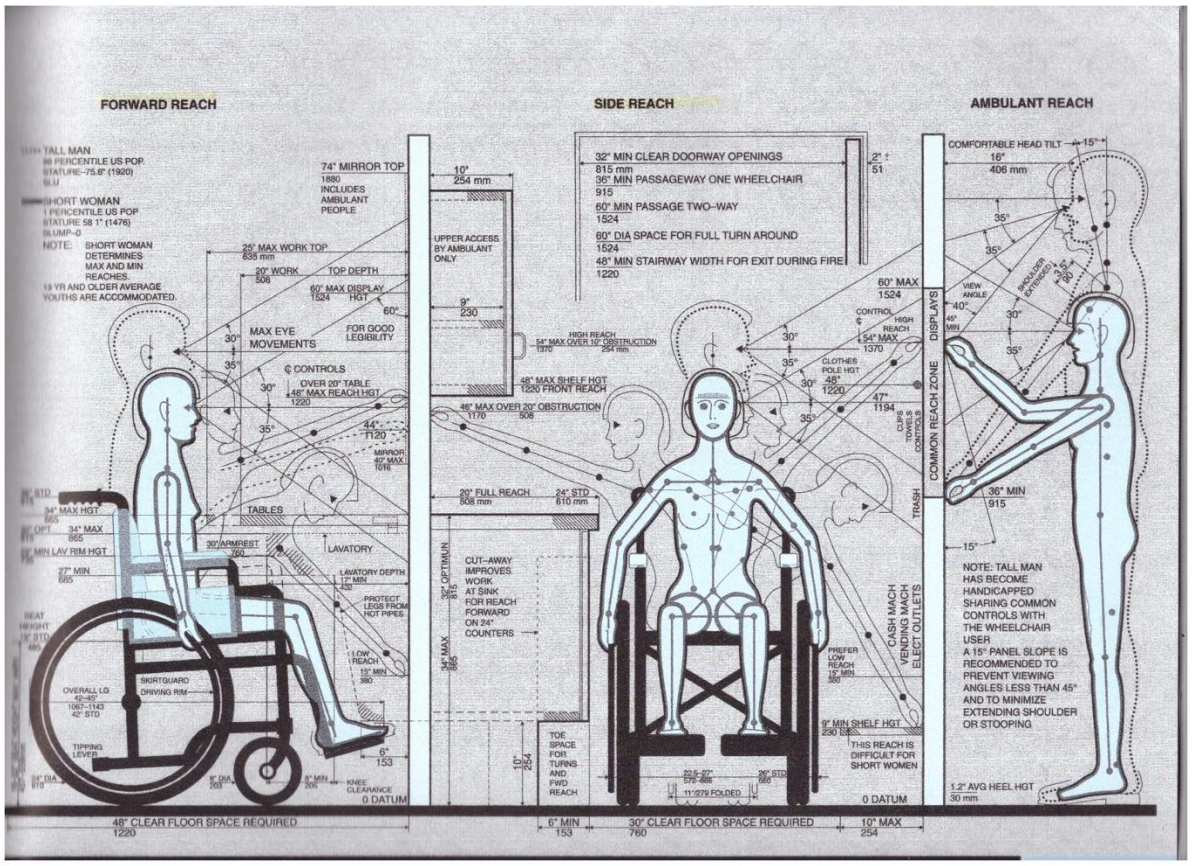


Figure 28:Reach for Wheelchair User(Dreyfuss, 2002j)

3.1.7.1. Canes

There are two types of older adults who use cane tools, those with visual impairments and those with balance deficits.

Although the users are different, they all need to ensure that they have 24 inches of clear passing space. (If the outdoor exercise equipment is not customized for the user only, then the minimum clearance space is 36 inches.) They both need to be able to have a place to store their canes while they exercise, and it's best to store the canes close to or on the exercise equipment, even if they can work out safely away from the canes.

In Figure 29 the distance of the protrusion on the side or on the wall is shown. At above 27 inches the exercise equipment cannot protrude more than 12 inches. Based on this we can define that handrails on some activity equipment cannot protrude more than 12 inches at most when above 27 inches.

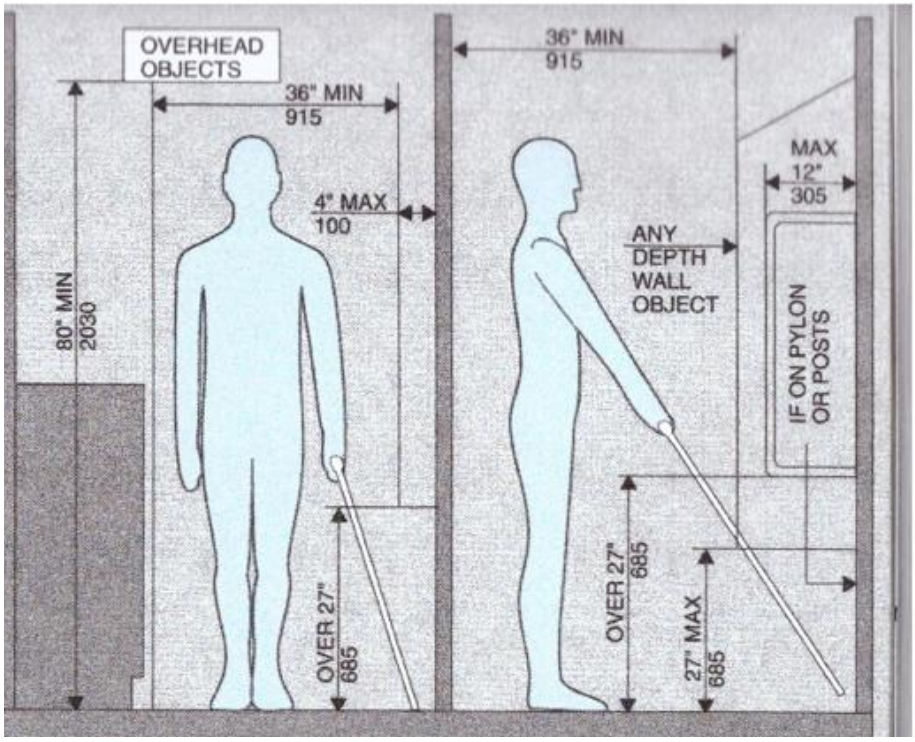


Figure 29: Reach of Canes(Dreyfuss, 2002e)

When designing outdoor exercise equipment, designers need to avoid protrusions or protrusions need to meet ADA standards. Below is the ADA definition of ground protrusions and the rules that need to be followed when designing outdoor exercise equipment for seniors.

> Freestanding objects mounted on posts or towers shall protrude from the circulation path a maximum of 12 inches (305 mm) at a minimum of 27 inches (685 mm) and a maximum of 80 inches (2030 mm) above the ground. Where signs or other barriers are mounted between posts or pylons and the clear distance between posts or pylons is greater than 12 inches (305 mm), the lowest edge of such signs

or barriers shall be a maximum of 27 inches (685 mm) or greater than or equal to 80 inches (2030 mm) (*ADA*, 2010a).

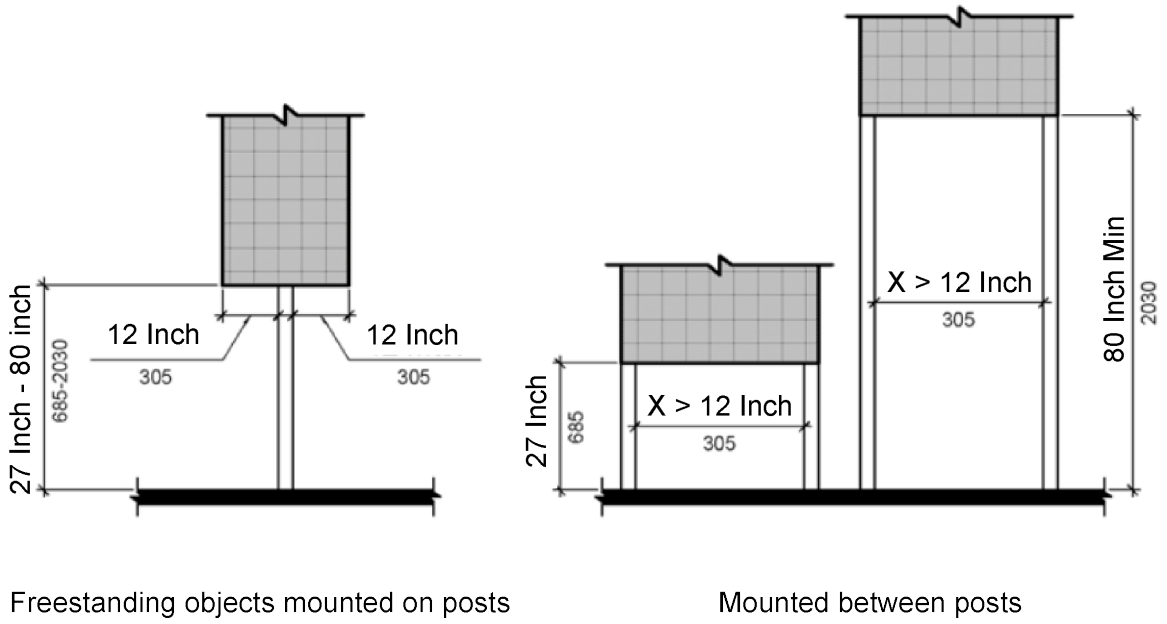


Figure 30: Protrusion Dimension*(*ADA*, 2010a)*

3.1.7.2. Walker

Some seniors use walkers to help them keep their balance. When designing outdoor exercise equipment, designers need to consider how to use outdoor exercise equipment safely and comfortably even when older adults use walkers. Through the previous survey, there is sufficient strength in the arms and shoulders of older adults who use walkers.

As shown in Figure 26, seniors using walker aids need to have 28 inches of clear space for passage. (If the outdoor exercise equipment is not customized for the user only, then the minimum clearance space is 36 inches.) Designers should add handrails to the exercise equipment, which are positioned 34 to 38 inches from the floor of the equipment to assist older adults who use walkers or who do not have sufficient lower-body strength.

3.1.7.3. Wheelchair

In this section the clear floor space, knee clearance, toe clearance, turning space, and reach of the wheelchair user will be addressed. Designers need to follow this dimensional information to create outdoor exercise equipment for the elderly and disabled.

3.1.7.3.1. Ground Space

Designing outdoor exercise equipment for the elderly and elderly people with disabilities is bound to include wheelchair users, and when it comes to wheelchair users the designer should first think of the wheelchair space. The following is the ADA definition of wheelchair space that designers need to refer to. However, this information should be improved, because the ADA requires space based on the definition of the chase small value. In the production process there is inevitably an error, so designers need to increase the minimum by 2 inches to avoid errors so that wheelchair users will also be more comfortable. The standards indicate that "The ADA has minimum standards for the extent of wheelchair space, with a ground space of at least 30 inches (760 mm) by 48 inches (1220 mm)" (*ADA*, 2010a).

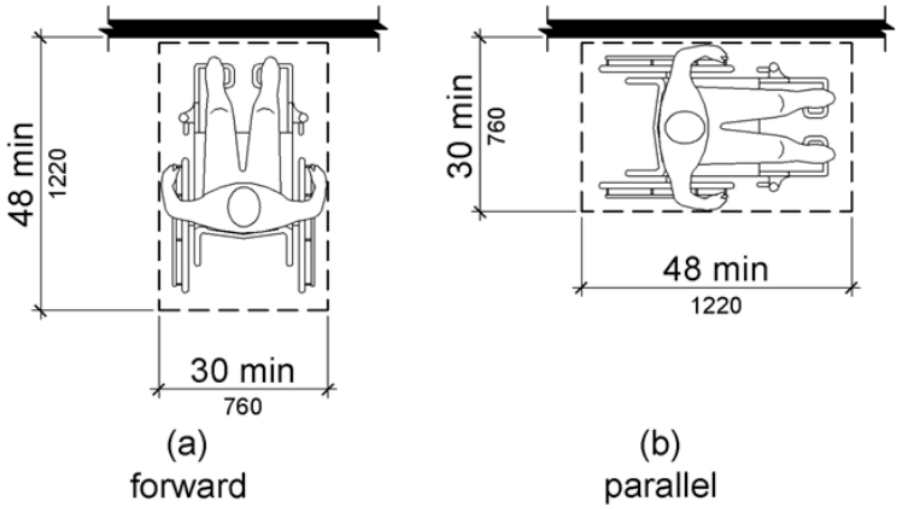


Figure 31: Ground Space*(*ADA*, 2010a)*

Industrial designers should also think about toe clearance and knee clearance, without which wheelchair users would have difficulty reaching objects in front of them and would be in danger. These clearances are mentioned in the ADA standard and industrial designers need to follow them:

> If there are objects or platforms above the wheelchair use space then a minimum height of 9 inches (230 mm) above the ground space needs to be retained, with a minimum depth of at least 17 inches (430 mm) and a maximum depth of 25 inches (635 mm) with a minimum width of 30 inches (760 mm) for toe clearance (*ADA*, 2010a).

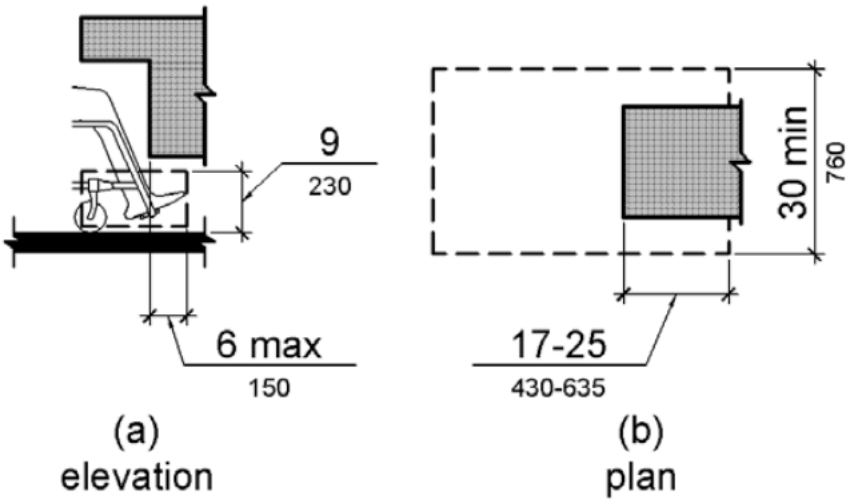


Figure 32: Toe Space*(*ADA*, 2010a)*

In addition, the standards state:

> The space below the element between 9 inches (230 mm) and 27 inches (685 mm) above the ground is considered knee clearance. The knee clearance shall extend below the element 9 inches above the ground a maximum of 25 inches (635 mm) for maximum depth and 11 inches (280 mm) for minimum depth. The knee clearance shall be a minimum of 30 inches (760 mm) wide (*ADA*, 2010a).

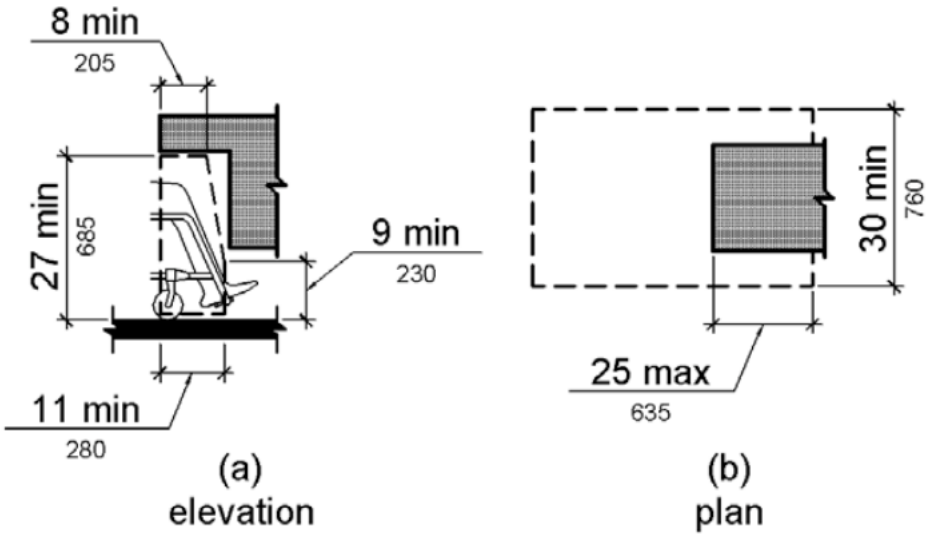


Figure 33: Knee Space*(*ADA*, 2010a)*

3.1.7.3.2. Reach Range

There are two types of reach for wheelchair users, the reach to the front and the reach to the side.

Reach range cannot be separated from anthropometrics. Because there is too much data, the specific information will not be listed one by one. The following picture is the anthropometric data when the elderly use wheelchairs. The image includes small female, large male, and average adult specific data. Designers can refer to the specific data when designing the outdoor exercise equipment for the elderly and elderly with disabilities (Henry Dreyfus's Associate, 2002).

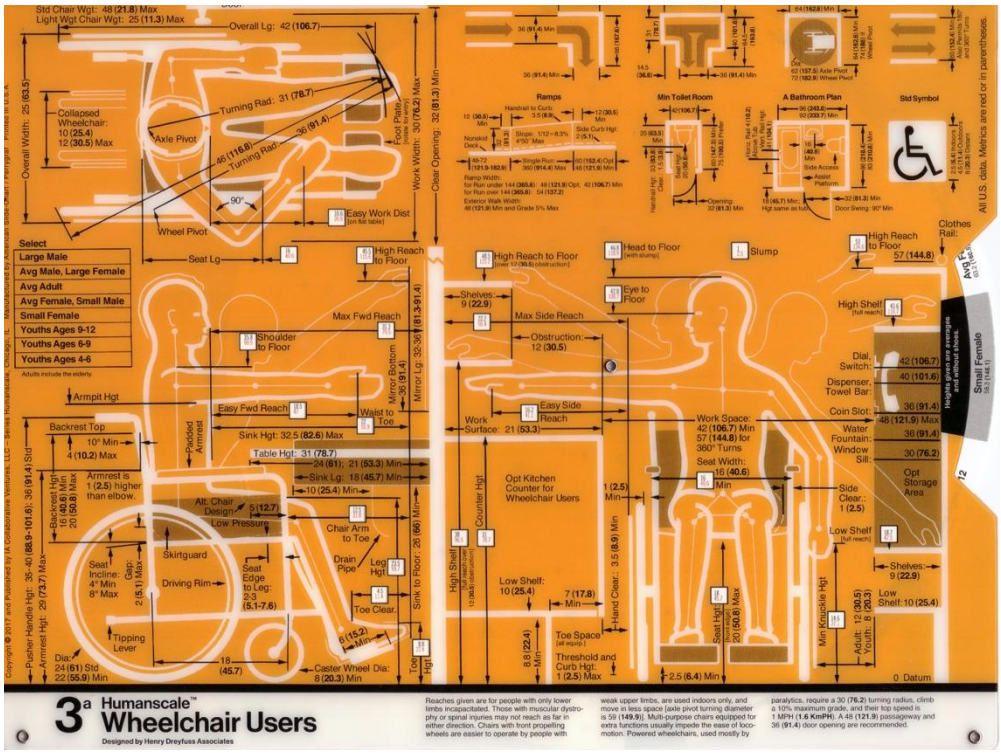


Figure 34: Small Female Wheelchair Users(Dreyfuss, 2002f)

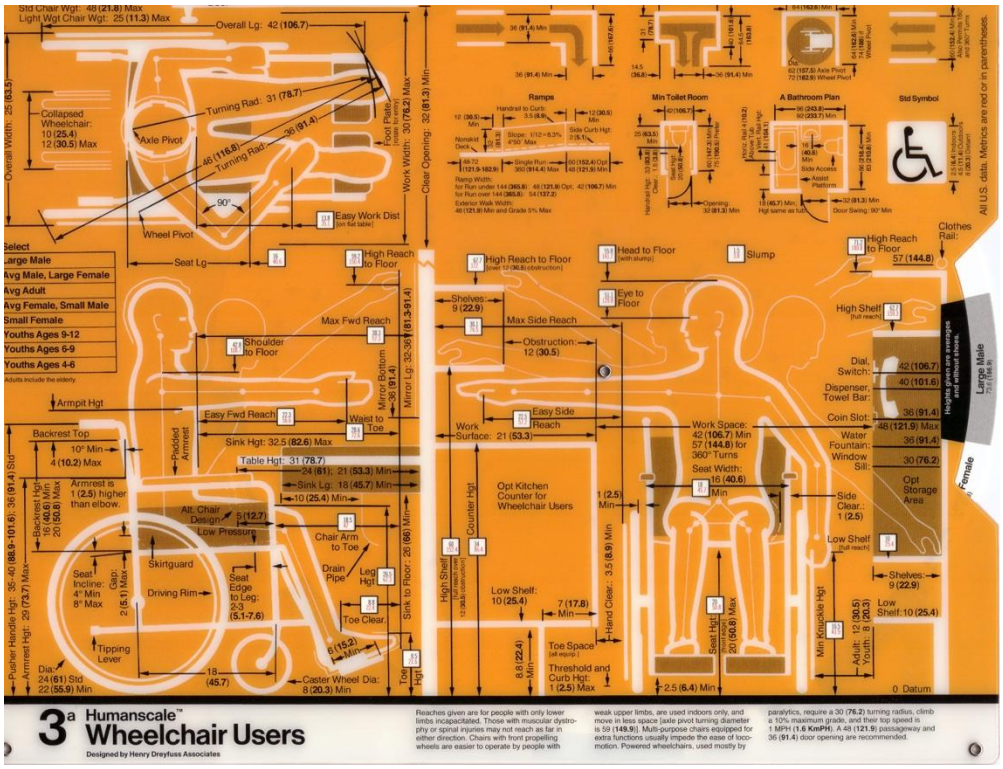


Figure 35: Large Male Wheelchair Users(Dreyfuss, 2002f)

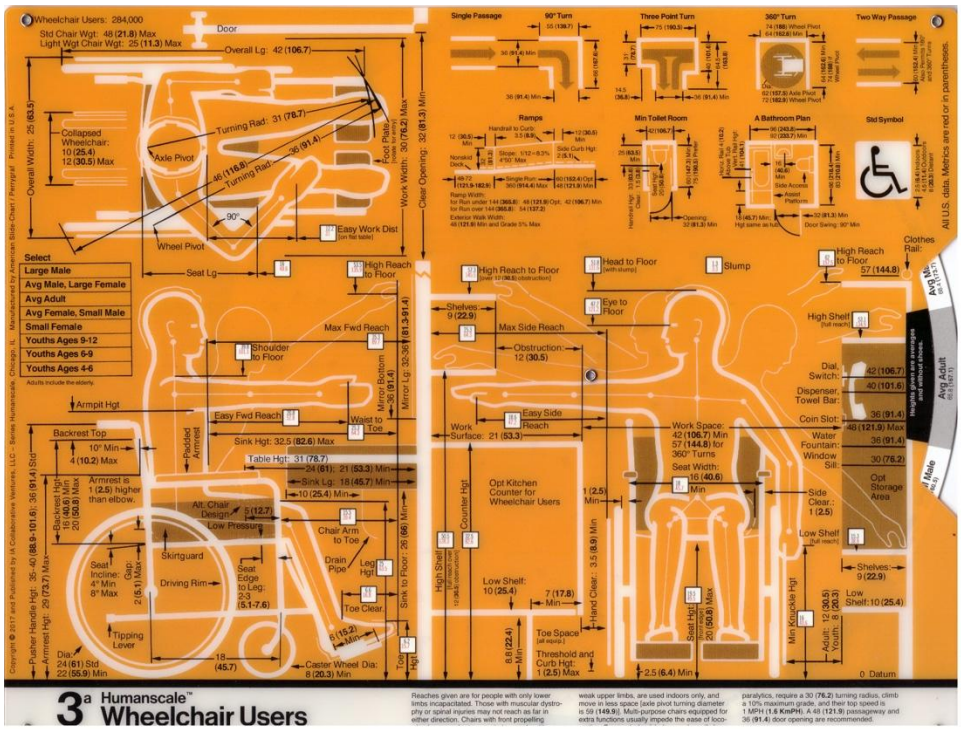


Figure 36: Average Adult Wheelchair Users(Dreyfuss, 2002b)

Both reach ranges should follow ADA standards, but elderly persons' upper body does become shorter, so their high reach to floor will be lower than the ADA standard.

3.1.7.3.2.1. Forward Reach

Below is an ADA Standard to Forward reach. The high reach to floor is 48 inches: "Forward Reach: Where a forward reach is unobstructed, the high forward reach shall be 48 inches (1220 mm) maximum and the low forward reach shall be 15 inches (380 mm) minimum above the finish floor or ground" (*ADA*, 2010a).

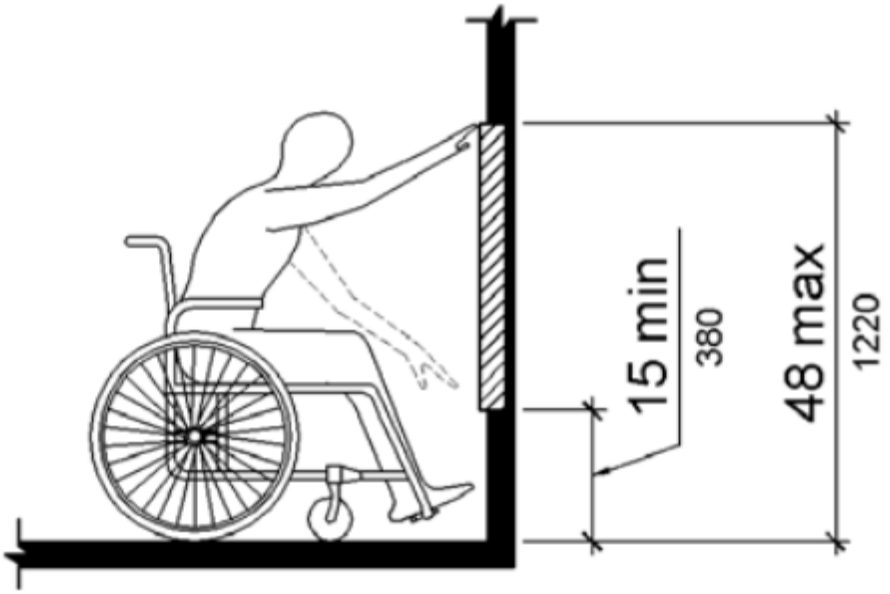


Figure 37: Forward Reach*(*ADA*, 2010a)*

But in figure 21's small female anthropometry date, the elderly small female high reach to floor is 45.5 inches. So, 48 inches is out of that part of the reach range. So, I have based the wheelchair reach range on the new data of 45.5 inch as the new wheelchair user reach height.

As designers in the design of outdoor exercise equipment for the elderly and elderly disabled, we cannot only consider the laws and regulations, but we also design products that should first consider the user. The design should be people oriented. Designers need to have the ability to analyze data.

3.1.7.3.2.2. Obstructed High Reach

Designers need to understand about obstructed high reach. For example, outdoor equipment will have some protrusions, so these protrusions need to be designed taking into account how deep wheelchair users can accept protrusions that also do not affect the wheelchair user while using the outdoor exercise equipment. According to the ADA standards:

Obstructed High Reach: Where a high forward reach is over an obstruction, the clear floor space shall extend beneath the element for a distance not less than the required reach depth over the obstruction. The high forward reach shall be 48 inches (1220 mm) maximum where the reach depth is 20 inches (510 mm) maximum. Where the reach depth exceeds 20 inches (510 mm), the high forward reach shall be 44 inches (1120 mm) maximum and the reach depth shall be 25 inches (635 mm) maximum (*ADA*, 2010a).

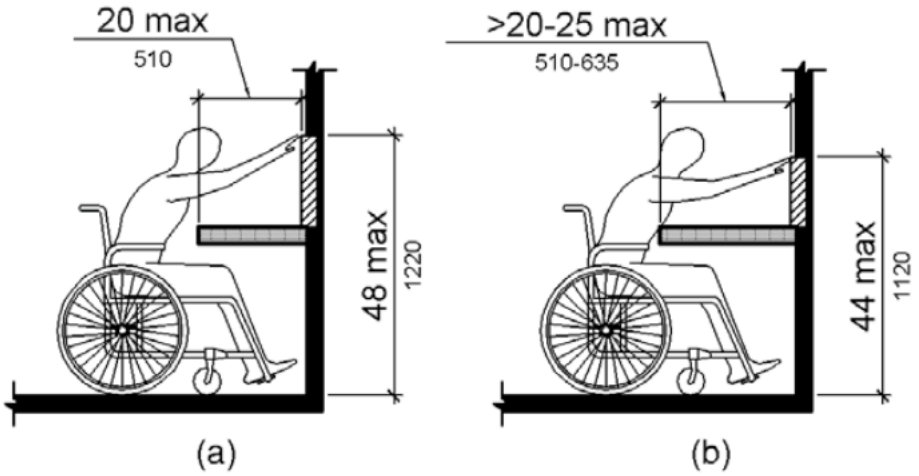


Figure 38: Obstructed High Forward Reach*(*ADA*, 2010a)*

Based on anthropometric data and the requirements given in the ADA standard regarding obstructed high reach, it is possible to define the dimensions for the elderly and elderly with disabilities according to the specifications of the ADA standard.

3.1.7.3.2.3. Side Reach

From the side, small females can side reach to a height of 53 inches. but the ADA standard of 48 inches will be the maximum high reach. The lower reach limit is 10 inches for both 99% of men and 1% of women.

Based this date, I will use 48 inches as max high reach and a lower reach minimum of 10 inches. The standards define side reach as:

> Where a clear floor or ground space allows a parallel approach to an element and the side reach is unobstructed, the high side reach shall be 48 inches (1220 mm) maximum and the low side reach shall be 15 inches (380 mm) minimum above the finish floor or ground (*ADA*, 2010a).

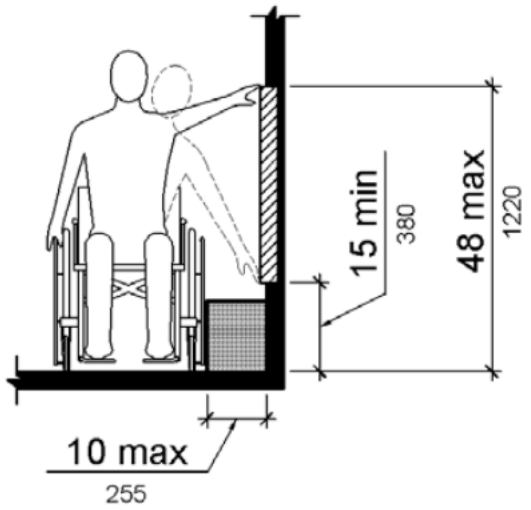


Figure 39: Side Reach*(*ADA*, 2010a)*

3.1.7.3.2.4. Obstructed Side High Reach

When reach is obstructed, small females can reach to a height of 48.5 inches. But the ADA standard states 48 inches will be the max high reach for 10 inches obstructed, with a max 46-inch-high reach for 10 to 24 inches obstructed. The ADA standard data is less low than anthropometry data.

Based this data, for safety I will use ADA standard for max size. 48 inches are the max obstructed high reach for 10 inch obstructed; 46 inches are a max obstructed high reach for 10 to 24 inches obstructed.

Obstructed Side High Reach: Where a clear floor or ground space allows a parallel approach to an element and the high side reach is over an obstruction, the height of the obstruction shall be 34 inches (865 mm) maximum and the depth of the obstruction shall be 24 inches (610 mm) maximum. The high side reach shall be 48 inches (1220 mm) maximum for a reach depth of 10 inches (255 mm) maximum. Where the reach depth exceeds 10 inches (255 mm), the high side reach shall be 46 inches (1170 mm) maximum for a reach depth of 24 inches (610 mm) maximum (*ADA*, 2010a).

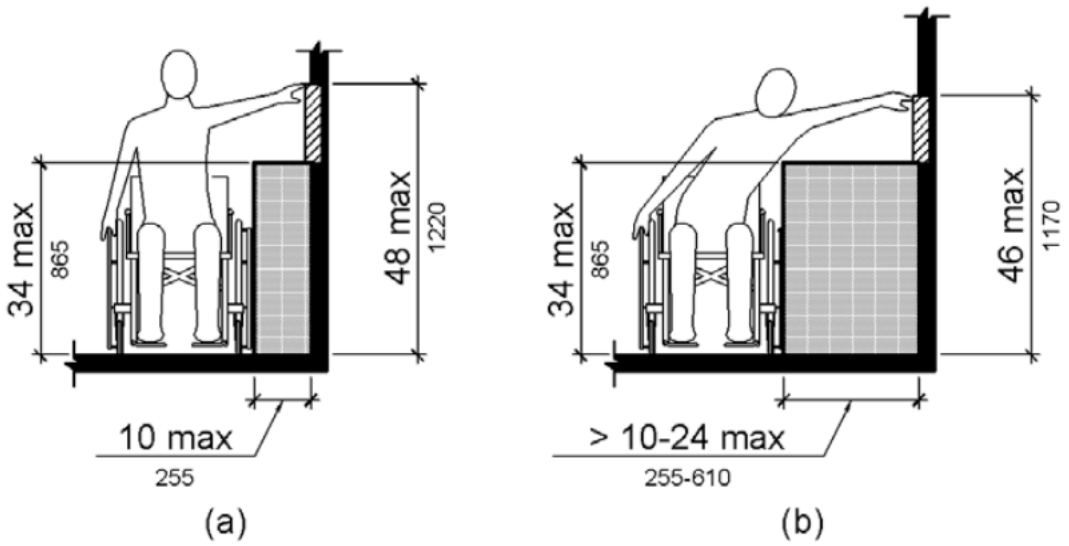


Figure 40: Obstructed Side High Reach*(*ADA*, 2010a)*

3.1.7.3.3. Turn Space

Turn space is important for wheelchair users; if the space is too small, it's not enough to turn, and then move throughout the area. So, designers need to know the space for wheelchair turning. Normally for outdoor exercise, the wheelchair turn type is a T turn and 360 degrees.

3.1.7.3.3.1. T Turn Space

When designing outdoor exercise equipment for elderly and elderly with disabilities, the equipment makes available space for wheelchair turns smaller. Therefore, the user cannot do the T turn and then when the wheelchair user uses outdoor exercise equipment, they will feel uncomfortable. The anthropometry and ADA standards state wheelchair users make a T turn. The ADA standard is a lower standard, so if designers want users to feel comfortable, we should increase the ADA standard of a T turn size of 2 inches or more. Below is the ADA standard T turn dimension.

> Changes in level are not permitted in the floor space of the wheelchair turning space. Turning in a circular space shall be a minimum of 60 inches (1525 mm) in diameter. In a T-shaped space, the turning space should be a minimum of 60 inches (1525 mm) square T-shaped space with arms and base at least 36 inches (915 mm) wide. each arm of the T should be free of obstructions at least 12 inches (305 mm) in each direction and the base should be free of obstructions at least 24 inches (610 mm). At the base or end of one arm only. (*ADA*, 2010a)

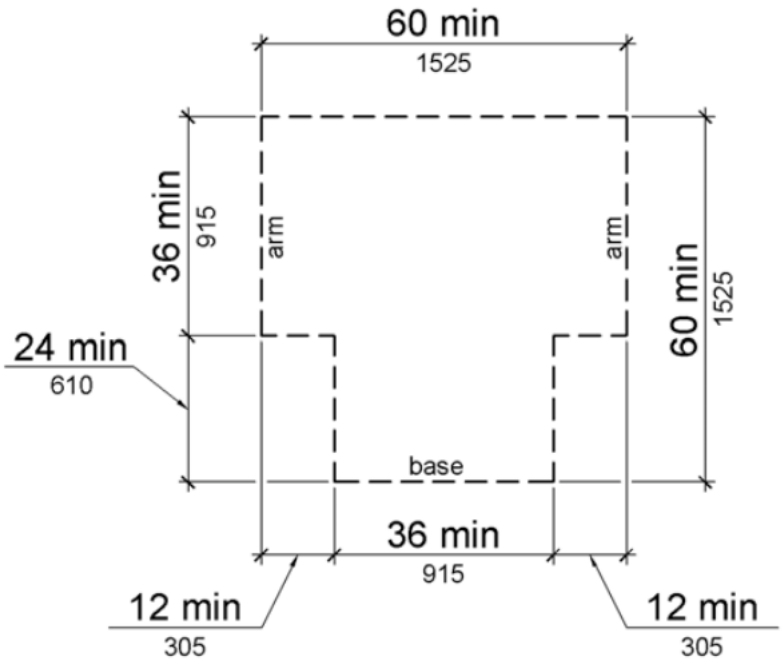


Figure 41: T Turn Space*(*ADA*, 2010a)*

3.1.7.3.3.2. 360 Turn Space

A 360 degree turn space is more than the T turn space. According to the ADA the standard 360 degree turn should be 60 inches in diameter. But a 60-inch diameter is a minimum size, so if designers want users comfortable, they should add 4 inches or more.

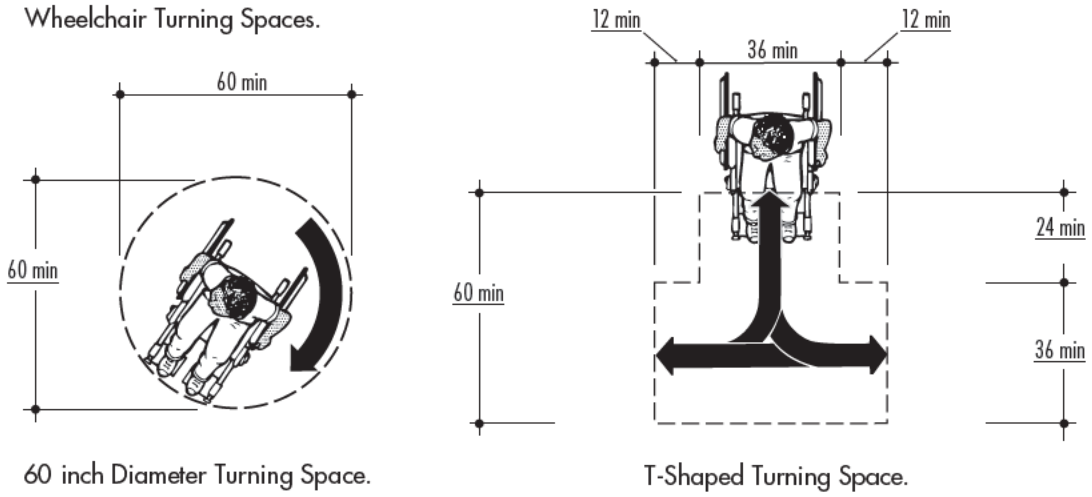


Figure 42: ADA Standard 360 Turn & T Turn Space*(*ADA*, 2010a)*

3.1.8. Accessible Routes

Accessibility is one of the most important conditions for the elderly and disabled to get around, and if there is no accessibility, some people will be unable to get around. For example, wheelchair users will not be able to pass steps or uneven surfaces. Users of canes and walkers will have difficulty in maintaining balance and some people with visual impairments will find it more difficult to move around. According to ADA regulations, walking surfaces that are part of an accessible route should comply with the walking surface regulations.

> The running slope of the walking surface should be no greater than 1:20. the cross slope should be no greater than 1:48. the net width of the walking surface should be a minimum of 36 inches (915 mm). the net width of the walking surface should be a minimum of 36 inches (915 mm). Net width of turn, if the accessible route makes a 180-degree turn around a width of less than 48 inches (1220 mm), the net width at the approach to the turn shall be at least 42 inches (1065 mm) The net width of the turn shall be at least 48 inches (1220 mm) and at least 42 inches

(1065 mm) away from the turn. If the clear width at the turn is greater than or equal to 60 inches (1525 mm) it may remain 36 inches (915 mm) at the turn (*ADA*, 2010a).

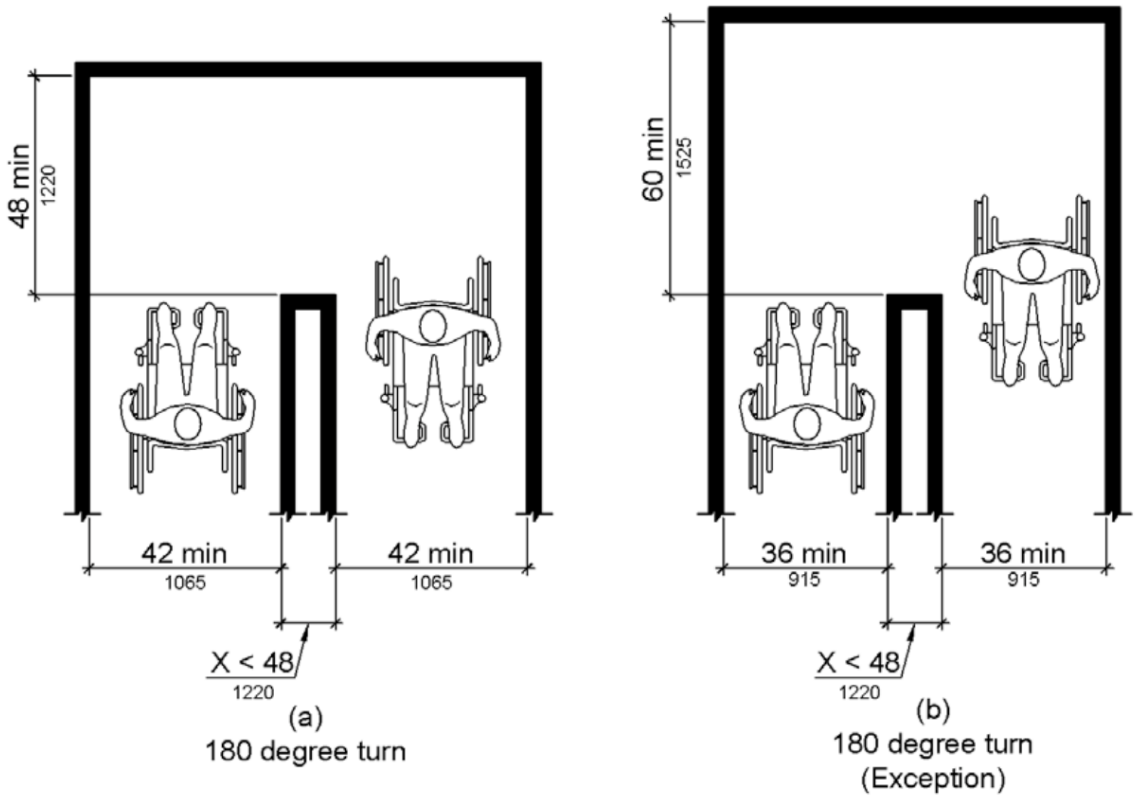


Figure 43: Clear Width at Turn*(*ADA*, 2010a)*

3.1.8.1. Ramps

The ADA has specific guidance for ramps and handrails, as stated below:

Handrails should be provided at some ramps. The minimum height is 34 inches (865 mm) and the maximum height is 38 inches (965 mm). The outside diameter of handrail gripping surfaces with a circular cross-section shall be a minimum of 1 1/4 inches (32 mm) and a maximum of 2 inches (51 mm). Handrail gripping surfaces with a non-round cross-section shall have a minimum perimeter dimension of 4 inches (100 mm) and a maximum dimension of 6 1/4 inches (160 mm), with a maximum cross-section dimension of 2 1/4 inches (57 mm). (*ADA*, 2010a)

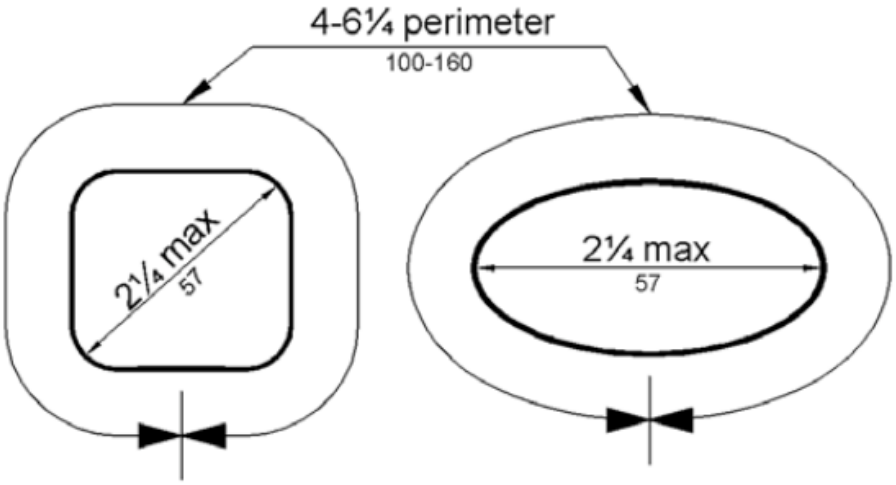


Figure 44: Handrail Non-Circular Section*(*ADA*, 2010a)*

Furthermore:

Handrail gripping surfaces and any surfaces adjacent to them shall be free of sharp and corrosive elements and have rounded edges. Handrails shall not rotate within the fitting. Ramp handrails shall extend horizontally above the platform at least 12 inches (305 mm) from the top and bottom of the ramp. (*ADA*, 2010a)

Figure 44 and 45 shows the measurements and placements of handrails on ramps.

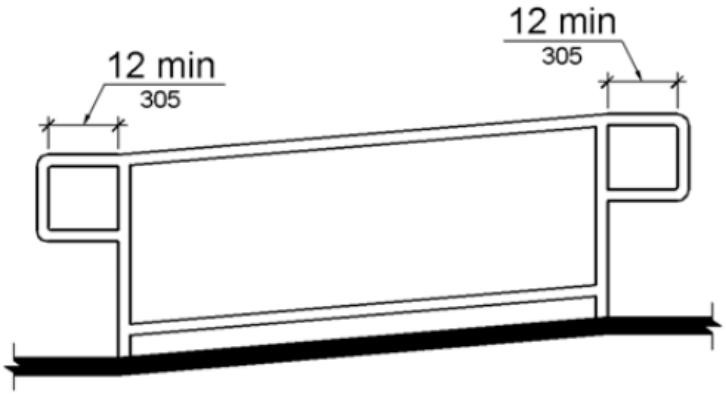


Figure 45: Handrail Extension at Ramps*(*Handrail Extension at Ramps ADA*, 2010)*

3.2. Avoid

Through some experience and reading the ASTM standard, the following design and production precautions are summarized in the hope of avoiding unforeseen situations.

1) Shear, pull-in and crush points shall be avoided or protected. The junction of two oppositely moving parts, or the opening at the junction of a fixed and rigid support member of a swinging part, shall not have an extrusion or shear point as the swinging part passes through its full range of travel.
2) There shall be no accessible sharp points or sharp edges on outdoor exercise equipment.
3) All edges of outdoor exercise equipment are free of burrs and sharp edges.
4) All corners in accessible areas should be curved or chamfered.
5) All exposed open ends of tubing must be fitted with caps or plugs that cannot be removed without the use of tools.
6) All dimensions need to be ADA compliant, allowing for above standard but not below standard.
7) Protrusion hazards shall not be present on outdoor exercise equipment.
8) Any accessible bolt end projecting beyond the face of the nut more than two full threads is an entanglement hazard.
9) Some fixed spaces should be greater than 9 inches or less than 3 inches. For small children 3 inches to 9 inches is a dangerous space.
10) There should be a smooth coating in the place where the skin touches to avoid abrasion.
11) Designers should avoid using colors indiscriminately when designing outdoor exercise equipment for seniors.
12) Rounded or curved corners should be used as much as possible to avoid accidental injury.
13) Handrails within easy reach to prevent sudden falls where there is no place to hold on to.

3.3. Consider

1) Outdoor exercise areas need to have accessible routes. Accessible routes should be a width of 36 inches, ramp slope is 1:12, and turn space should be a 60 inches diameter.
2) Outdoor exercise equipment that functions with a swinging or pendular motion shall be fitted with dampened end-stops or other appropriate movement limitation systems. End-stops shall be kept inaccessible. The portion of the equipment going through the pendulum motion shall not exceed a range of motion of over 60 degrees.
3) Handlebar / Grip Loading—Handlebars and gripping surfaces that support fully the user's body weight, shall meet the loading parameters of 135 kg (297 lb) without breakage. In general, handlebars or gripping surfaces that do not support the user's body weight shall endure a vertical static load of the greater of 1.0 × 135 kg (297 lb) or the maximum user weight without breakage. Handlebars and gripping surfaces shall endure a load of 0.5 × 135 kg (297 lb) in all other directions without breakage.
4) Outdoor exercise equipment minimum clearance space, outside of the training envelope for each piece of this equipment, shall be at least 36 inches (915 mm) in width.
5) How to design outdoor exercise equipment to make it more comfortable for the user.
6) Signs should be enlarged for easy reading, not be placed too high or too low, and should be placed within the visual area.

3.4. Flowchart

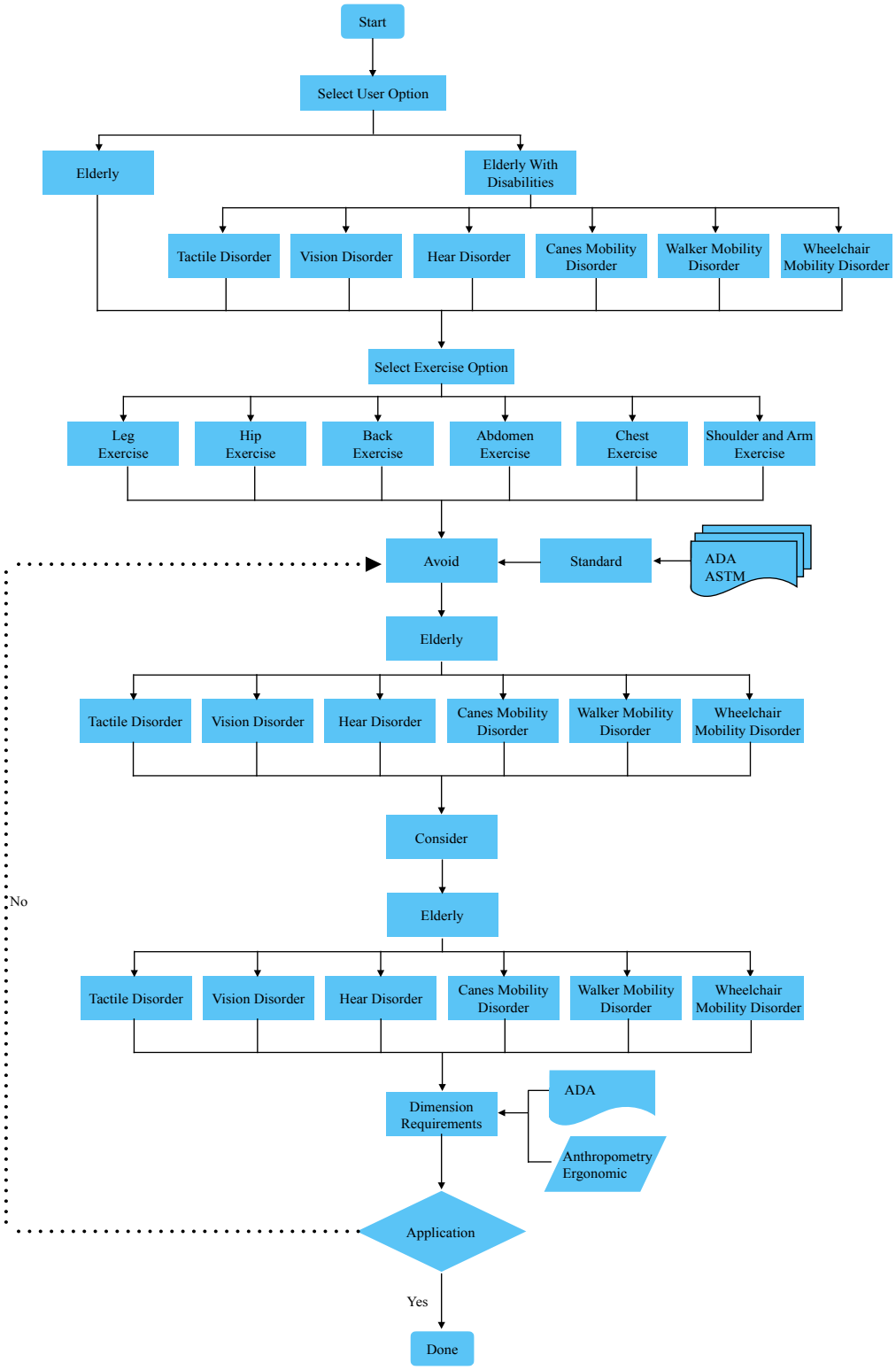


Figure 46: Flowchart

3.5. Conclusion

Table 1 Design Option

Guideline of Outdoor Exercise Equipment for Elderly and Elderly with Disabilities	
User Option (one or more)	
□ Elderly	
Elderly with Different Disabilities (If Any)	
□ 1. Tactile Disorder □ 2. Vision Disorder □ 3. Hear Disorder	□ 4. Canes Mobility Disorder □ 5. Walk Mobility Disorder □ 6. Wheelchair Mobility Disorder
Exercise Option (one or more)	
□ 1. Leg Exercise (go to table 2) □ 2. Hip Exercise (go to table 3) □ 3. Back Exercise (go to table 4)	□ 4. Abdomen Exercise (go to table 5) □ 5. Chest Exercise (go to table 6) □ 6. Shoulder and Arm Exercise (go to table 7)
First, the industrial designer needs to select the body part to be exercised (one or more) and then select different categories of seniors (one or more). Designers do this by drawing outlines using different colored pens or cutting them out with scissors and piecing them together. The designers can select the information they need themselves.	

Note: All avoidance and consideration will be based on an elderly basis. All letters with colors will be matched to diagram letters of the same color. Dimension Requirements go to table 8. See Chapter 3, "Requirements" for more details.

Table 2 Leg Exercise

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Leg Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

Table 3 Hip Exercise

	Avoid	Consider	Standard
Elderly	Hip Hyperextension Shear Edge/Point/Corner Step Over Height more than 5 inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Hip Rotation _H Non-slip Pedal Non-slip Handgrip Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Fall Out of the Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Place to Put Wheelchair Rest Place Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

Table 4 Back Exercise

	Avoid	Consider	Standard
Elderly	Shear Edge/Point/Corner Seat Over Height more than 16 inch Square or Angle Pipe/Part Protrusions other than equipment	Semantics Hip Rotation _H Arm &Shoulder Rotation _I Non-slip Pedal Non-slip Handgrip Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material Smooth Surface	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Fall Out of the Wheelchair Excessive Twisting Excessive Resistance	Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair	

Table 5 Abdomen Exercise

	Avoid	Consider	Standard
Elderly	Shear Edge/Point/Corner Seat Over Height more than 16 inch Square or Angle Pipe/Part Protrusions other than equipment	Semantics Hip Rotation _H Non-slip Pedal Non-slip Handgrip Seat Backrest Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material Smooth Surface	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Cane Mobility Disorder	Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out of the Wheelchair Excessive Twisting Excessive Resistance	Handrail on Ramp Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K	

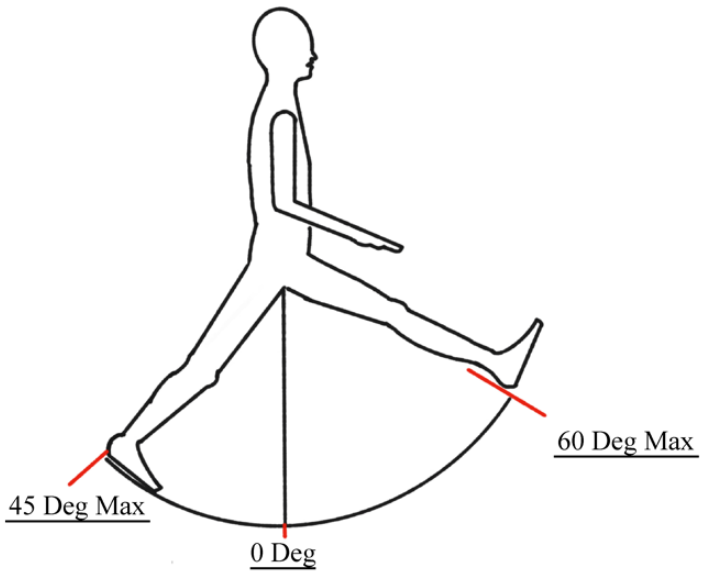
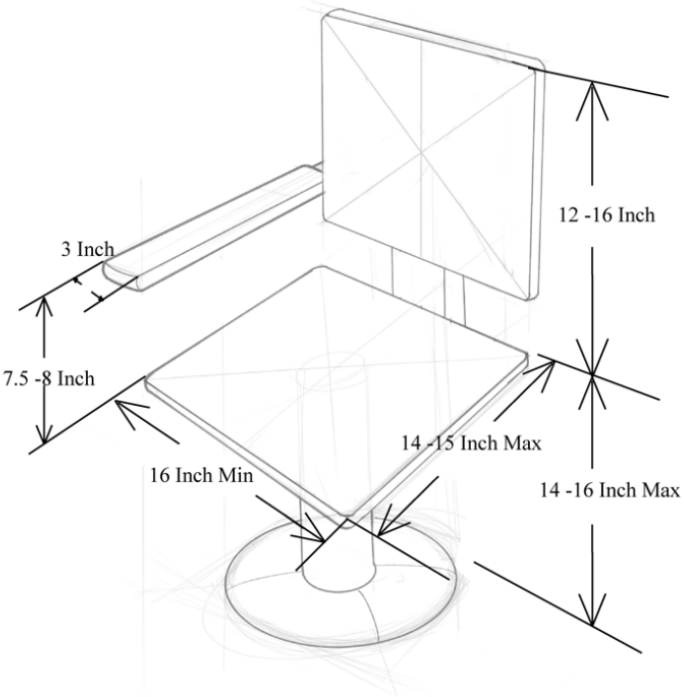
Table 6 Chest Exercise

	Avoid	Consider	Standard
Elderly	Seat Over Height more than 16 inch Square or Angle Pipe/Part Shear Edge/Point/Corner Protrusions other than equipment	Arm & Shoulder Rotation _I Non-slip Pedal Non-slip Handgrip Seating Dimension _B Semantics	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material Smooth Surface	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Place to Hold Canes Rest Place	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Place to Put Walker Rest Place	
Wheelchair Mobility Disorder	Falling Out of the Wheelchair Excessive Resistance	Handrail on Ramp Place to Put Wheelchair Rest Place Reach Range_ J Turn Space _K Handrail _G Accessible Routes _F	

Table 7 Shoulder and Arm

	Avoid	Consider	Standard
Elderly	Shear Edge/Point/Corner Seat Over Height more than 16 inch/Lower than 14 inch Square or Angle Pipe/Part Protrusions other than equipment	Arm & Shoulder Rotation _I Non-slip Pedal Non-slip Handgrip Seating Dimension _B Semantics	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material Smooth Surface	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Cane Mobility Disorder	Overstretching or Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Place to Hold the Canes Rest Place	
Walker Mobility Disorder	Overstretching or Excessive Twisting Excessive Resistance Fall	Handrail _G Accessible Routes _F Place to Put Walker Rest Place	
Wheelchair Mobility Disorder	Overstretching or Excessive Twisting Falling Out of Wheelchair Excessive Resistance	Handrail on Ramp Place to Put Wheelchair Rest Place Handrail _G Accessible Routes _F Transfer _L Reach Range_ J Turn Space _K	

Table 8 Dimension Requirements

Dimension Requirements	 Diagram A: Leg Rotation  Diagram B: Chair Dimension

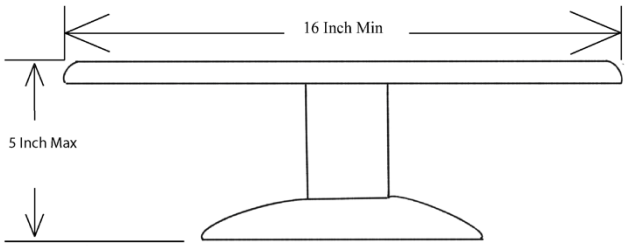
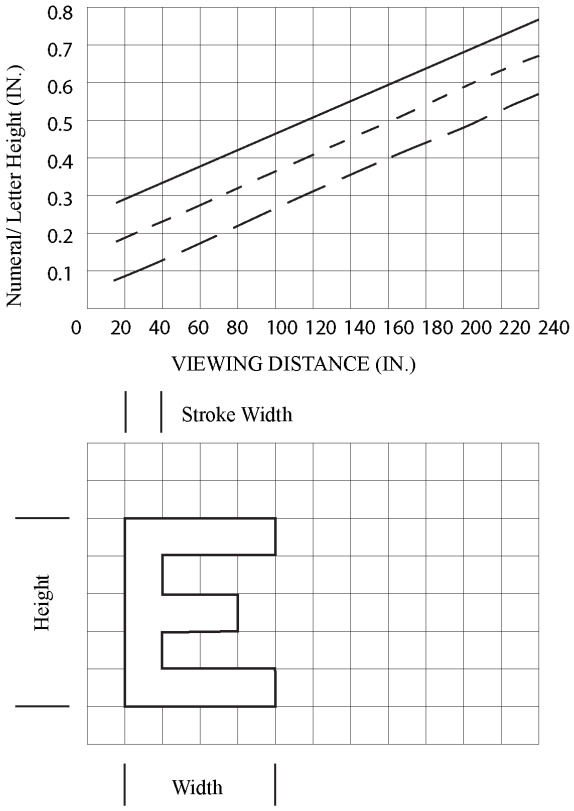


Diagram C: Step



Letter height versus viewing distance and illumination level (minimum space between characters, one stroke width; between words, six stroke width). (- For instruments where the position of the numerals may vary and the illumination is between 0.03 and 1.0 fL. - For instruments where the position of the numerals is fixed and the illumination is 0.3-1.0 fL, or where position of the numerals may vary and the illumination exceeds 1.0 fL. -- For instruments where the position of the numerals is fixed and the illumination is above 1.0 fL.)

Diagram D: Letter Height Versus Viewing Distance (Woodson et al., 1992)

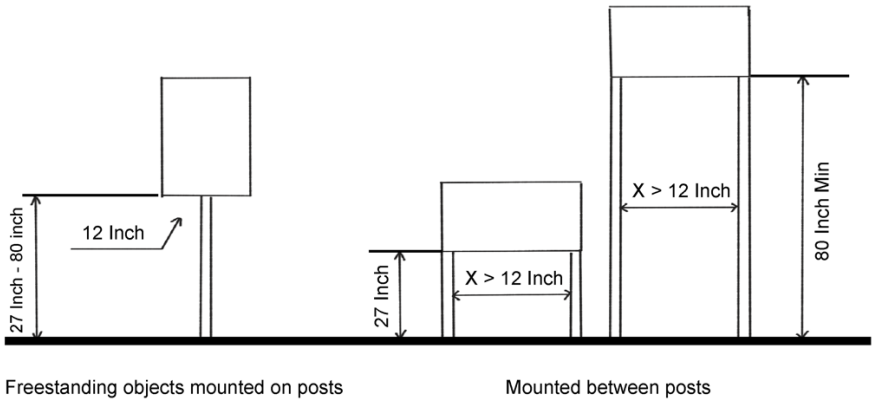


Diagram E: Protruding Object (*Protrusion Dimension*, 2010)

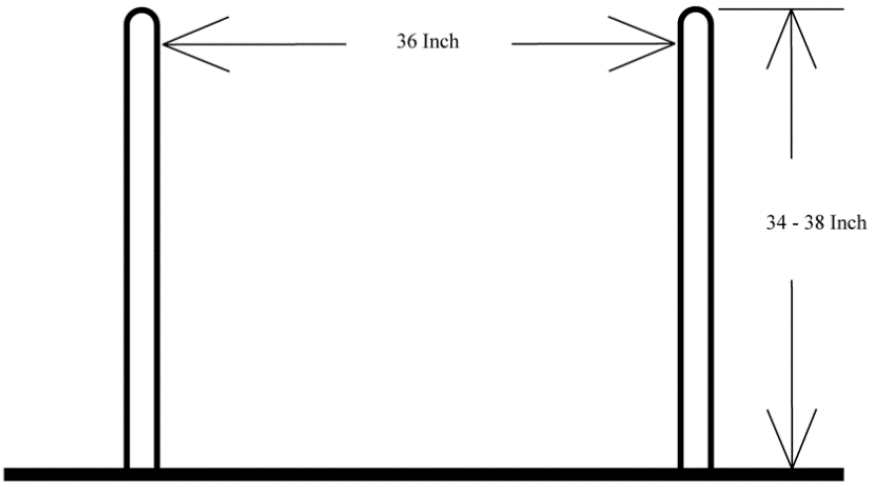


Diagram F: Accessible Route

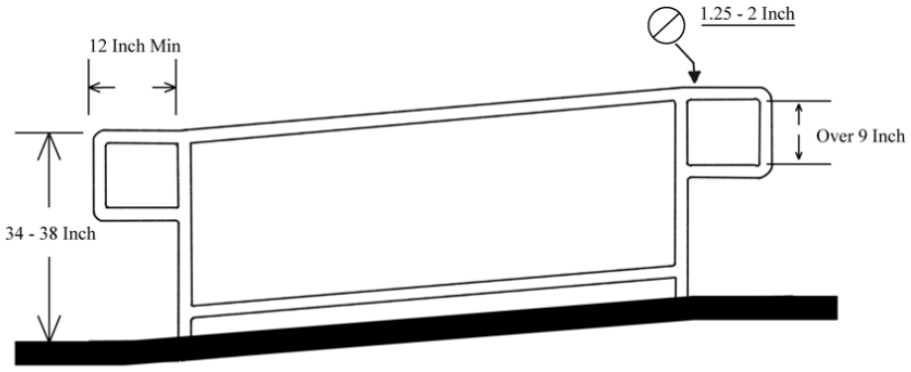


Diagram G: Handrail

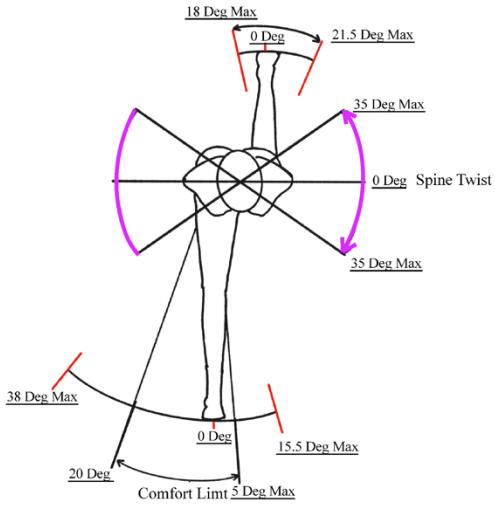


Diagram H: Hip Rotation

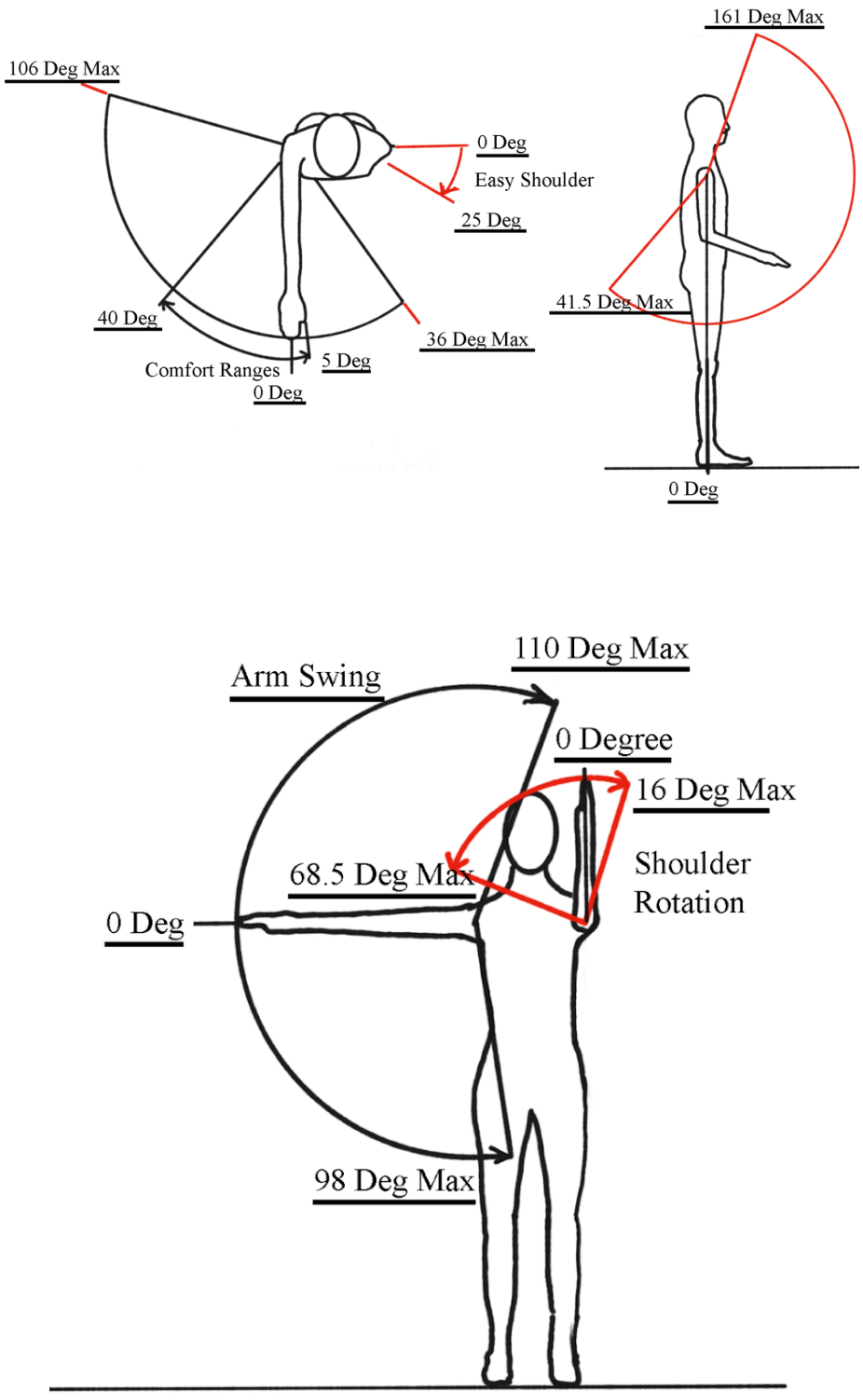


Diagram I: Arm & Shoulder Rotation

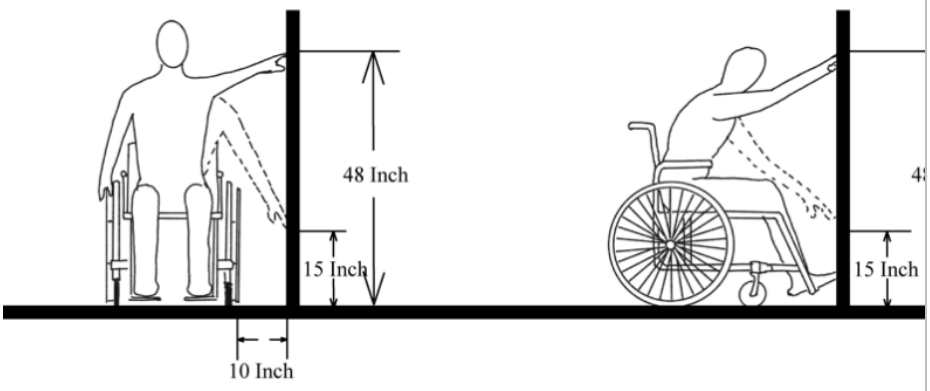


Diagram J: Reach Range

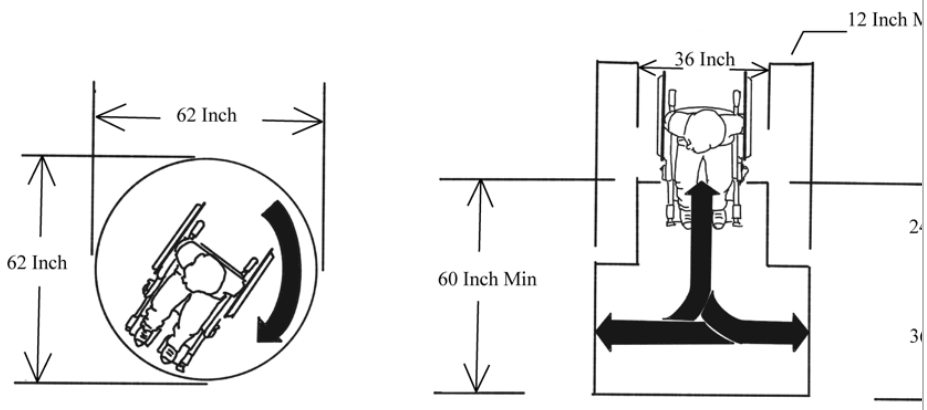


Diagram K: 360 Turning Space & T Turn Space

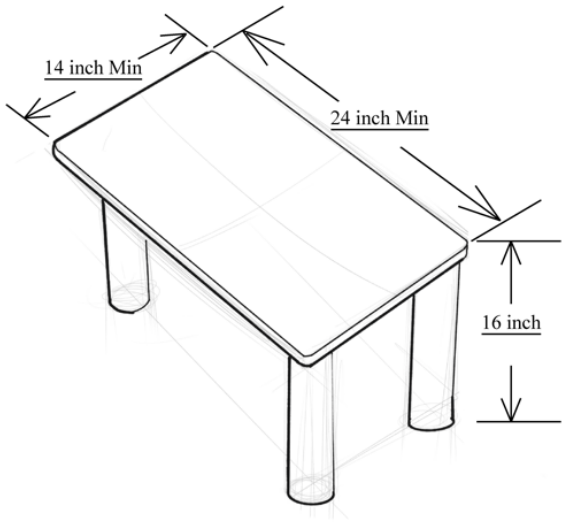


Diagram L: Transfer (wheelchair users use it to move to other places)

Chapter 4 Application

4.1 Planning

In this chapter, design decisions will be made based on the guidelines. The goal is to design outdoor exercise equipment for elderly and elderly with disabilities so that they can enjoy their life safely, comfortably, and happily.

4.1.1. User Choices

Due to aging or other reasons that will lead to physical disability of the elderly, I need outdoor exercise equipment that can be compatible with different physical qualities of the elderly, but the current exercise equipment cannot be compatible with this part of the population, so I will first select the user population. I chose the elderly and elderly with tactile impairments and the hearing-impaired elderly as the user groups.

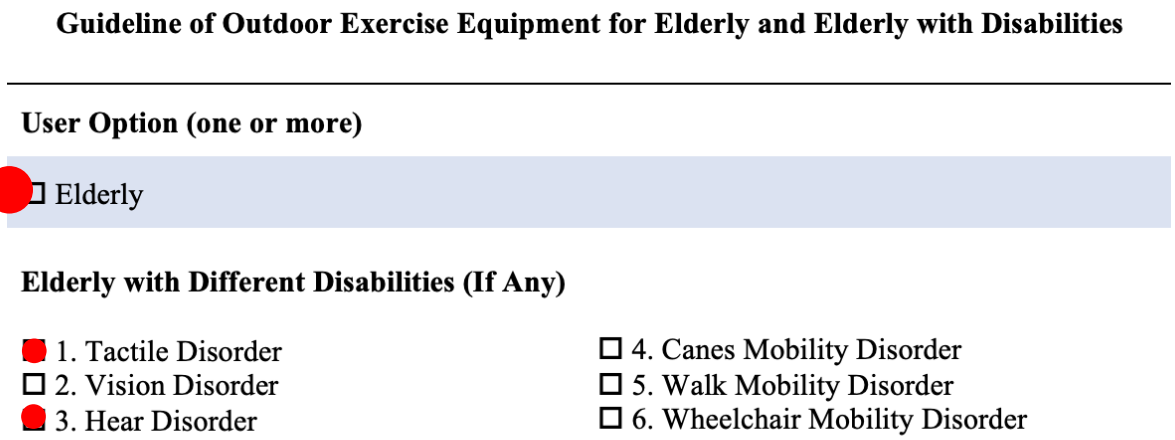


Figure 47: Guideline User Option

4.1.2. Exercise Choices

Because of the diversity of the human body, humans change more as they age, so when designing outdoor equipment, I need to consider what forms of outdoor exercise seniors need. What are some of the physical problems that can be helped by these types of outdoor exercise? Accidental falls are more common amongst older people and can be very dangerous. For this reason, I have chosen to use leg strengthening exercises. Leg strengthening exercises increase stability so that older people can keep their balance and are less likely to fall. It also makes the knee and hip joints more flexible.

Exercise Option (one or more)

- ● 1. Leg Exercise (go to table 2)
- ☐ 2. Hip Exercise (go to table 3)
- ☐ 3. Back Exercise (go to table 4)
- ☐ 5. Abdomen Exercise (go to table 5)
- ☐ 6. Chest Exercise (go to table 6)
- ☐ 7. Shoulder and Arm Exercise (go to table 7)

Figure 48: Guideline Exercise Option

4.2. Ideation

After exploring design options through ideation sketching (Figure 49), the concept in (Figure 50) was chosen as a final direction. The advantage of this design is that the elderly can enter and exit easily. There is no cover in the center, and those who have balance problems can hold the handrail to get in and out. At the same time, the information board is added to the design, which can make it easier for the elderly with visual impairment to read the information. The chair is ergonomically sized, and the handrail is ergonomically designed so that people with arthritis in their hands can grip it more easily. When the user finishes his workout and finds it difficult to stand up, he can grip the handrail in front of him to keep his balance. The soft rubber material on the handrail makes it more comfortable to grip.

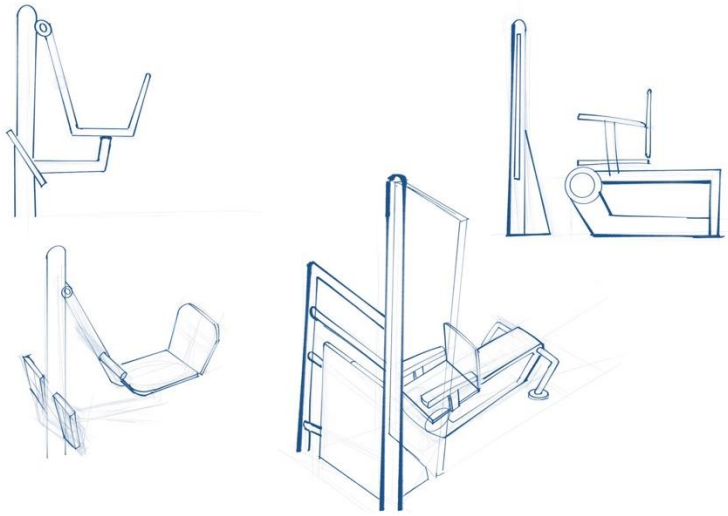


Figure 49: Ideation (Liang, 2024)

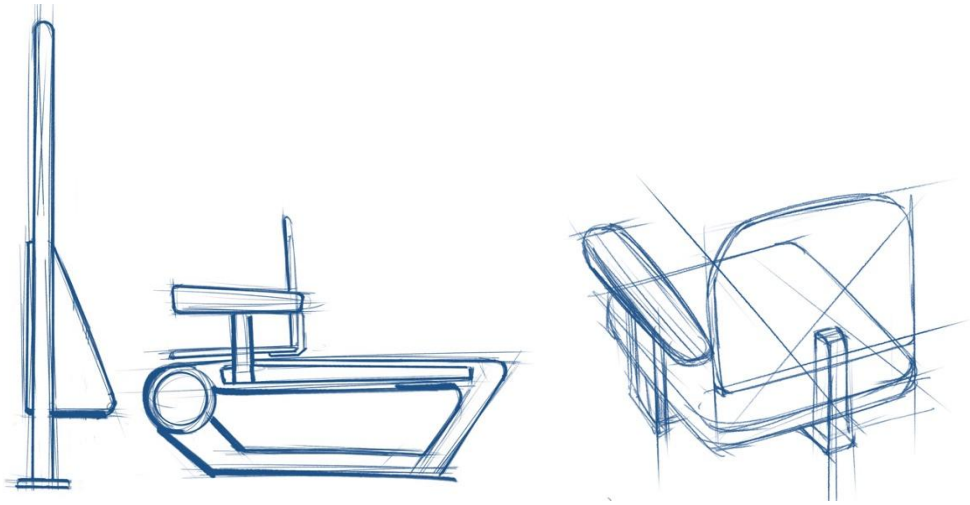


Figure 50: Ideation2 (Liang,2024)

4.3. Model Construction

In this section the process of making a model is explained in detail, from 3D modeling to 3D printing to assembly. The modeling process is slightly different from the actual factory production process, but due to the conditions it is not possible to make a physical model.

4.3.1. CAD Modeling

First, Figure 51 shows making the mechanical structure shell and seat support frame as a one-piece structure makes the product more stable.

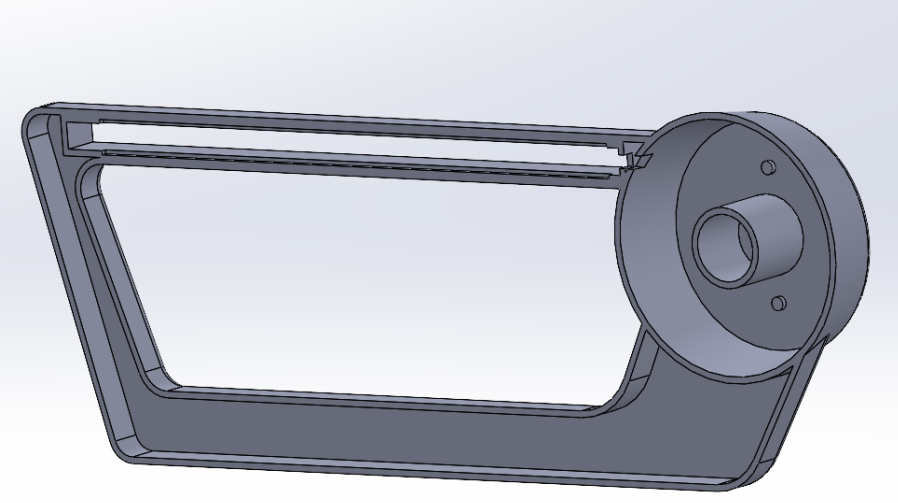


Figure 51: Half Mechanical Cover

Then the CAD is used to make a roller with a mechanical structure and a traction device. When the elderly finish exercising, the seat will automatically return to the initial position and increase resistance, so that the elderly can effectively exercise their leg muscles.

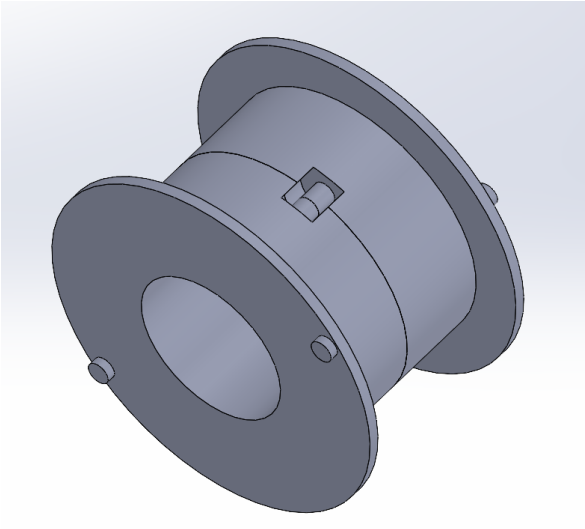


Figure 52: Roller

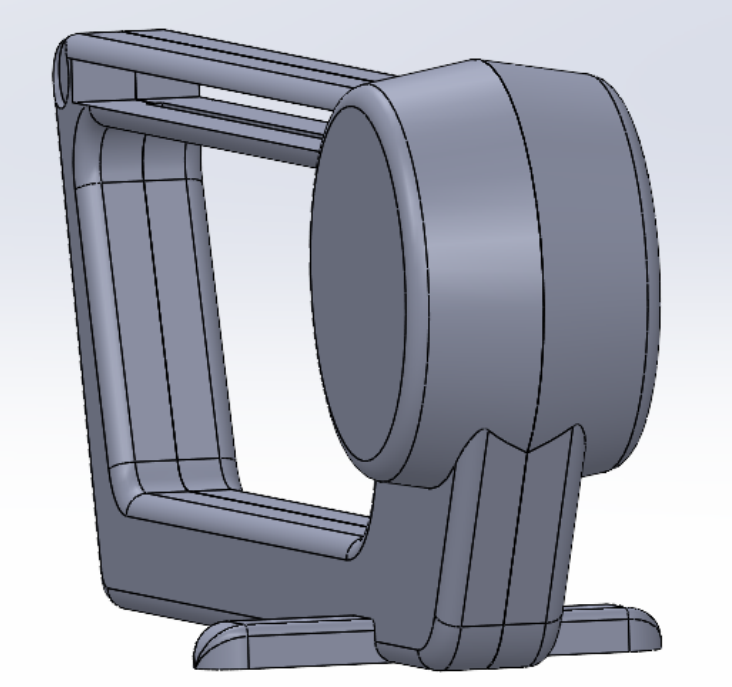


Figure 53: Mechanical Cover No Shear Edge

When making chairs, designers need to refer to the seat chair size data, based on the seat size data and ergonomics in hopes that the elderly can more comfortably use the apparatus.

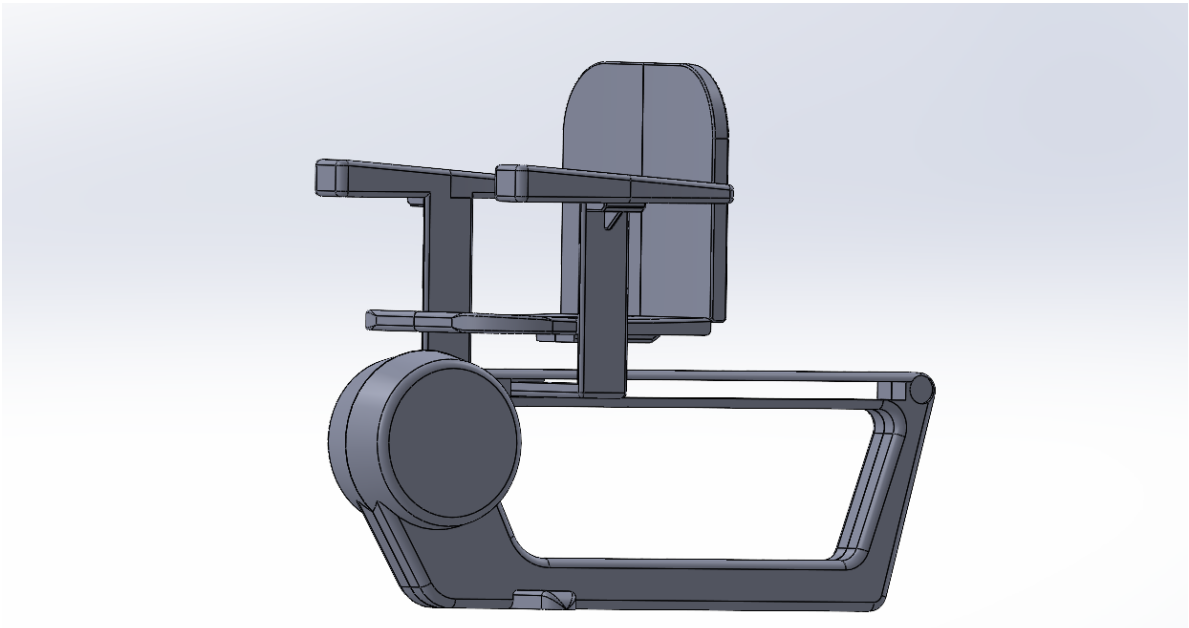


Figure 54: Chair and Mechanical Part

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

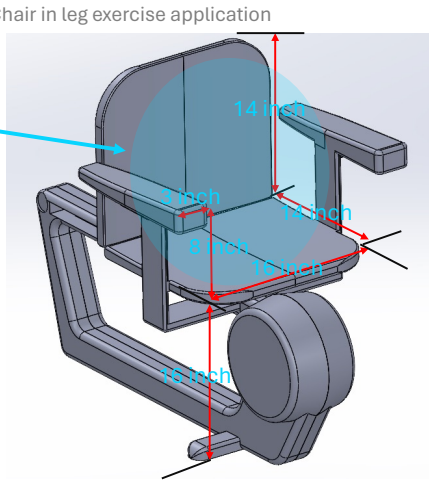


Figure 55: Guideline make Chair

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

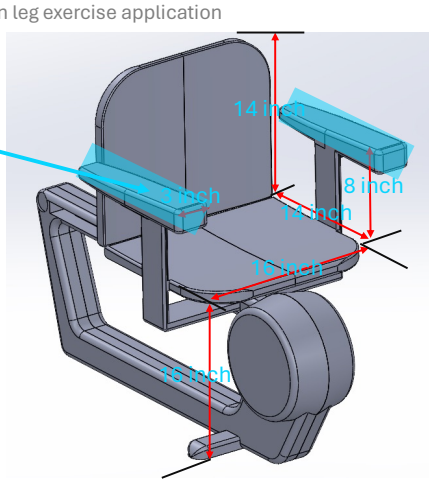


Figure 56: Guideline Make Armrest

The next step is to make an information board, handrail, and footrest. In this design the information board is connected to the handrail. There is a protruding section. The section is smaller than the ADA standard for protrusions at 12 inches. The handrail and footrest are made according

to the size of the handrail, which is divided into two layers. The upper layer of the handrail is 2 inches in diameter, the lower layer of the handrail is 1.5 inches in diameter, and the footrest is made according to the size of the step. The footrest is made according to the size of Step and is beveled so that the elderly can adjust the height according to the range of motion of their joints.

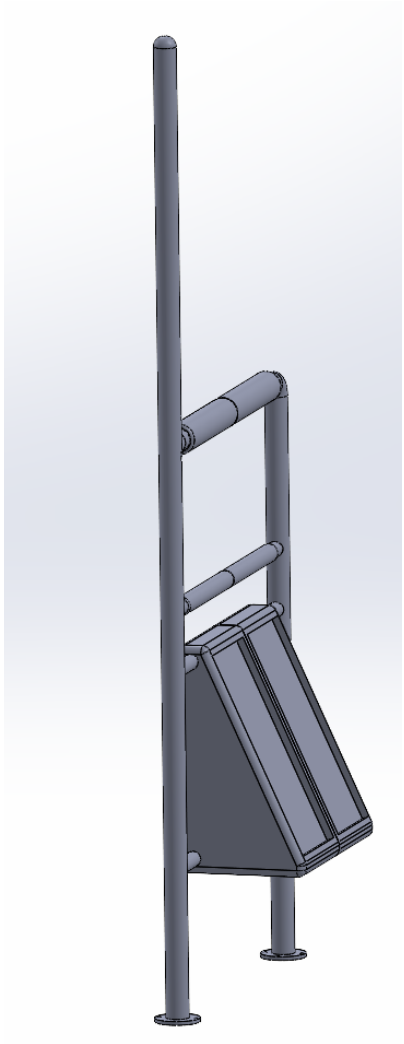


Figure 57: Handrail and Footrest

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

Non-slip Pedal in leg exercise application

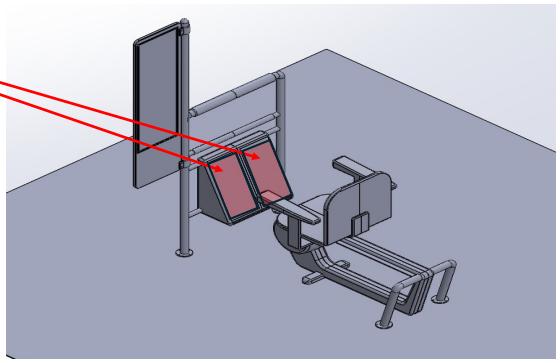
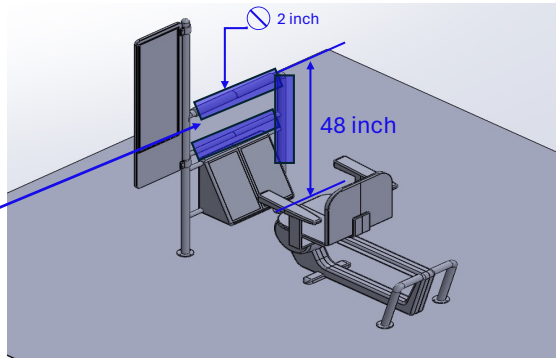


Figure 58: Guideline Make Footrest

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

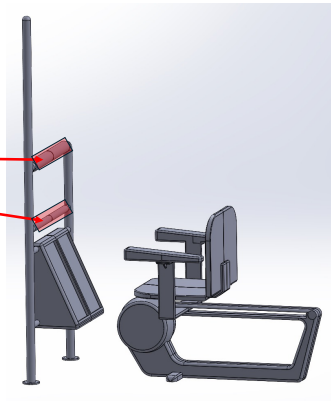


Handrail in leg exercise application

In this Leg Press, I have followed the guideline to make Handrail, Handrails are placed to prevent the elderly from falling,
Also, it will help elderly who could possibly have tactile or hearing disorders to get up or sit down.

Figure 59: Guideline Make Handrail

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	



In this Leg Press, I have followed the guideline to make soft material on handrail for Tactile Disorder people.

Figure 60: Guideline Make Soft Material

To create accessible routes, a 36 inches accessible route needs to be kept around the exercise equipment, which can be safeguarded for people with disabilities.

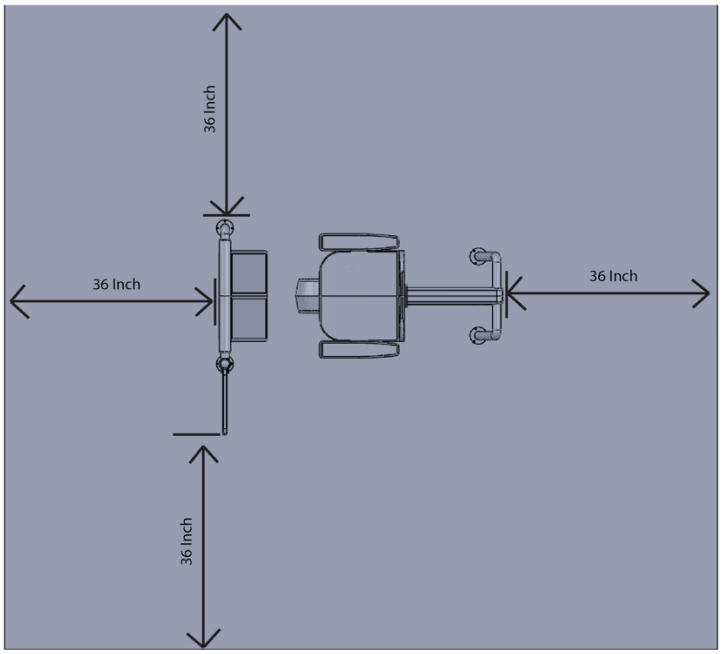


Figure 61: Accessible Route

4.3.2. Rendering

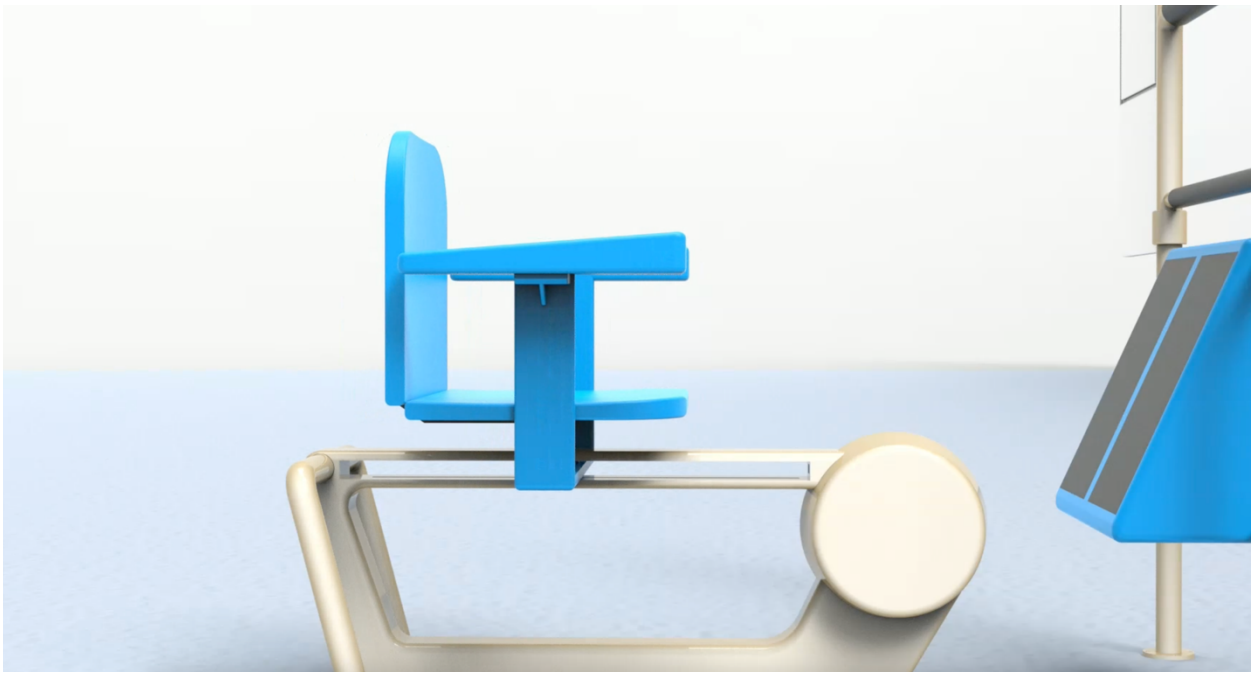


Figure 62: Rendering 1

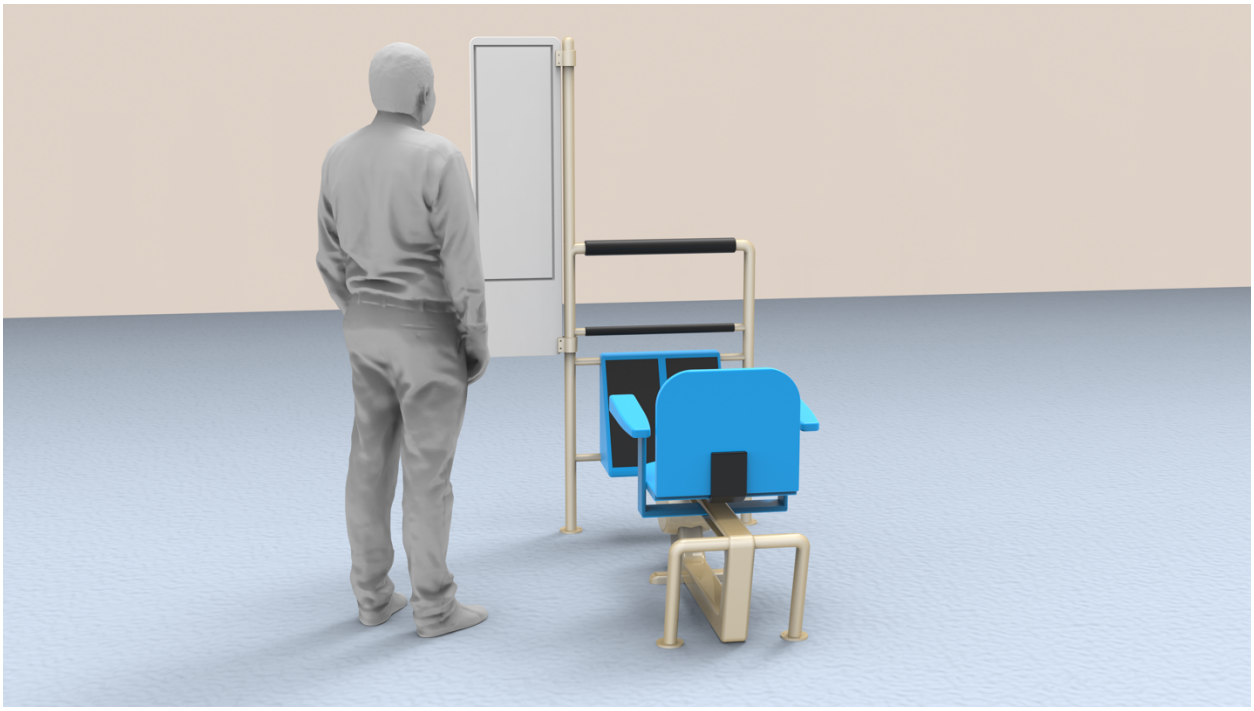


Figure 63: Rendering 2

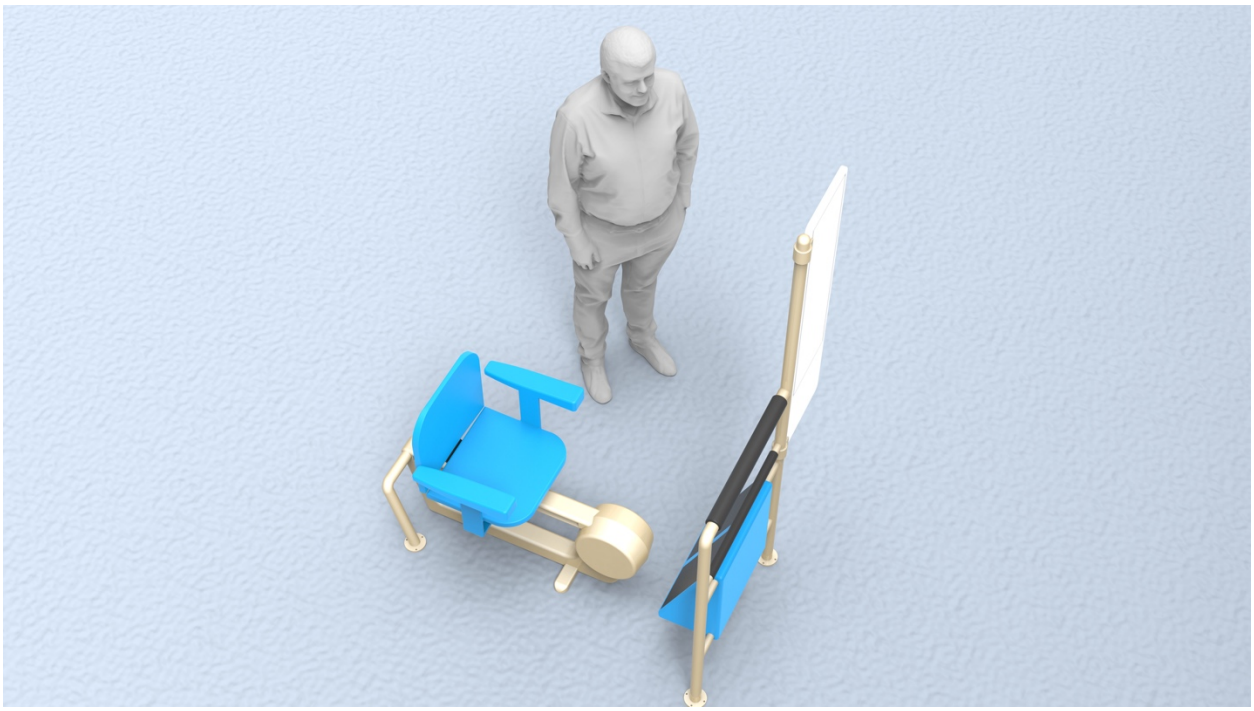


Figure 64: Rendering 3

Figure 65: Rendering 4

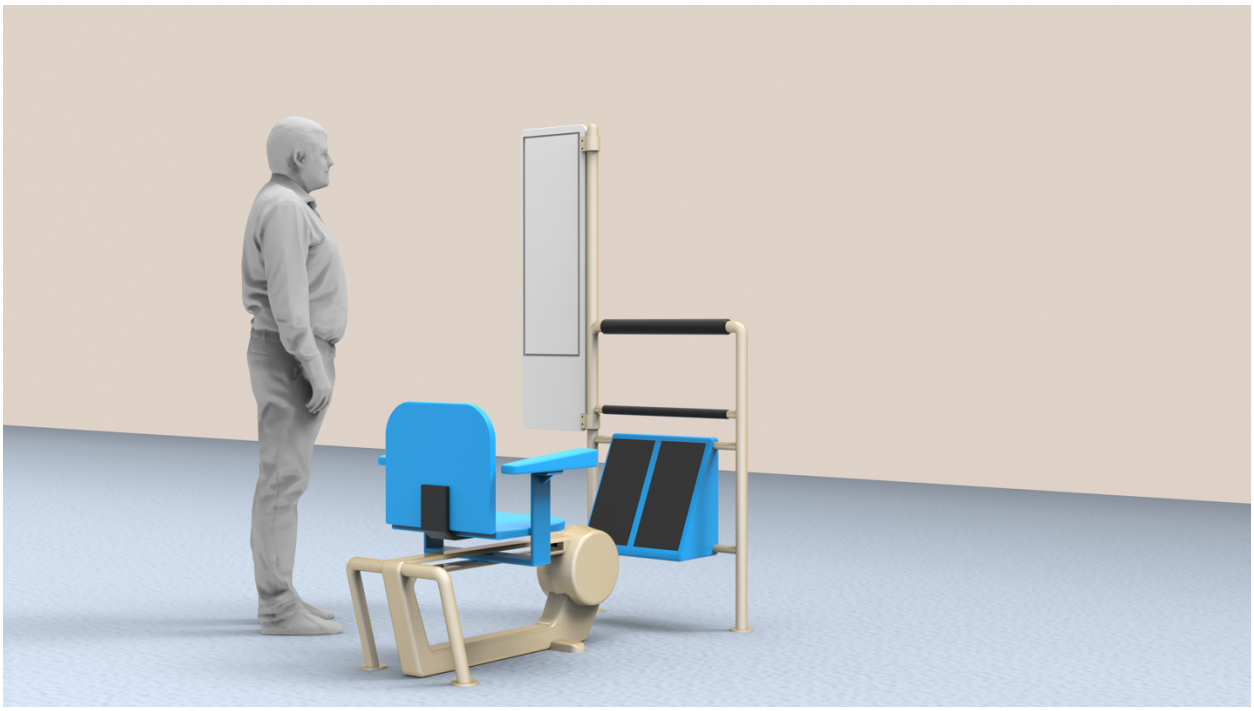


Figure 66: Rendering 5

Figure 67: Rendering 6

Figure 68: Rendering 7

Figure 69: Rendering 8

Figure 70: Rendering 9

Figure 71: Rendering 10

4.3.3. 3D Printing Model

In this section, 3D printing will be used to print models.

Figure 72: 3D Printing

3D printing a chair, rear leg, and a Step.

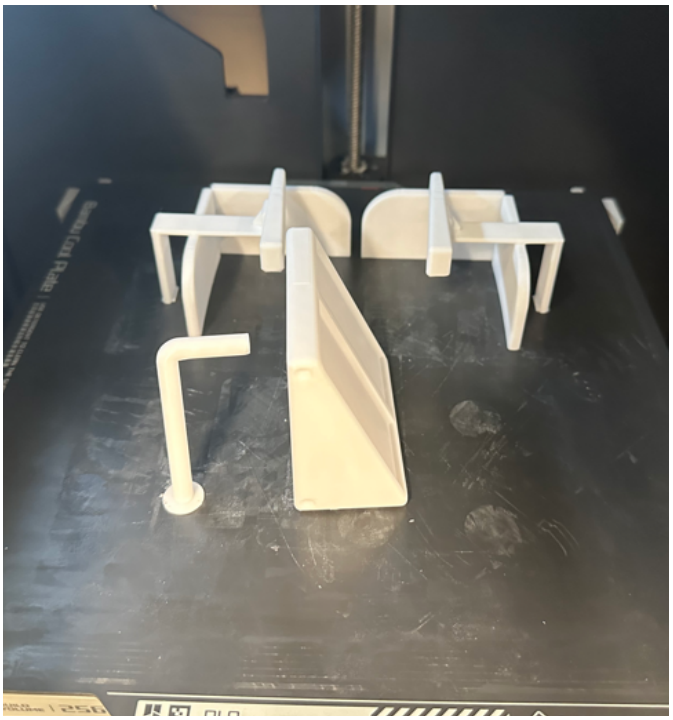


Figure 73: Chair, Rear Leg, and Step

3D printing a Mechanical Cover and Information Board.

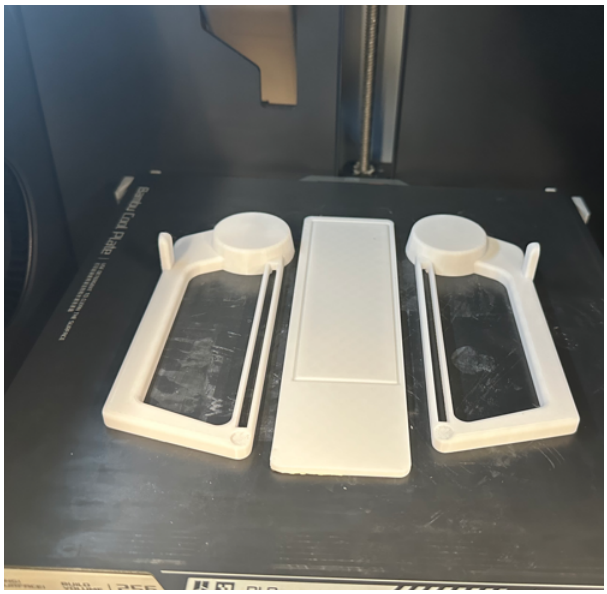


Figure 74: Mechanical Cover & Infor Board

4.3.4. Assembly 3D Model

This section shows the assembly of the printed parts.

Making Chair with Mechanical cover together.

Figure 75: Chair & Mechanical Cover

Figure 76: Chair & Mechanical Cover

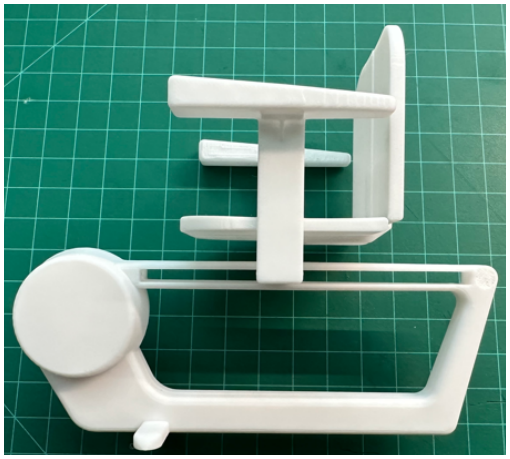


Figure 77: Side

Soft Rubber on the footrest; it can be anti-skid.

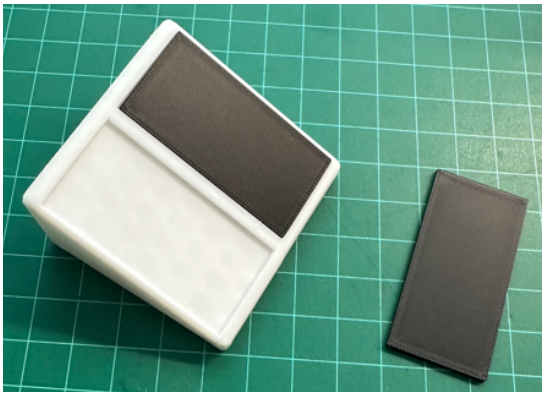


Figure 78: Footrest

Make handrail and footrest together.

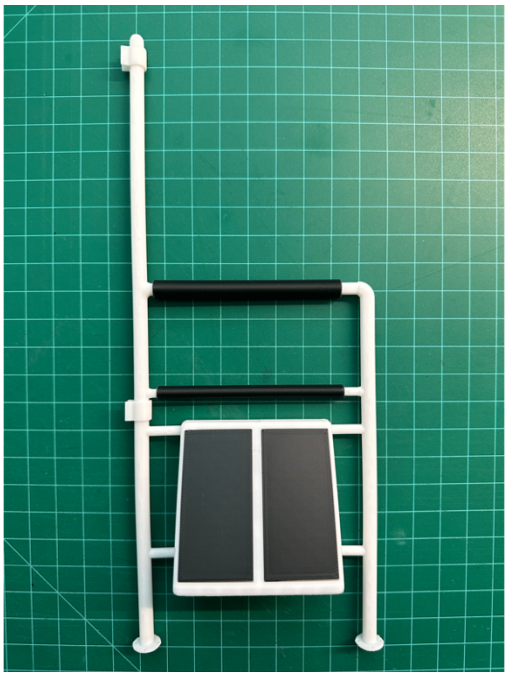


Figure 79: Handrail & Footrest

4.4. Air Walker Project

4.4.1. User Choose

Again, it is to choose the user population first. This time I chose elderly people, elderly people with tactile impairments, elderly people with vision impairments, elderly people with hearing impairments and elderly people with mobility aids as the user groups.

Guideline of Outdoor Exercise Equipment for Elderly and Elderly with Disabilities

User Option (one or more)

☑ Elderly

Elderly with Different Disabilities (If Any)

☑ 1. Tactile Disorder
☑ 2. Vision Disorder
☑ 3. Hear Disorder
☐ 4. Canes Mobility Disorder
☑ 5. Walk Mobility Disorder
☐ 6. Wheelchair Mobility Disorder

Figure 80: Choose User

4.4.2. Exercise Choose

Still choose the theme of designing exercise equipment for legs.

Exercise Option (one or more)

- ☑ 1. Leg Exercise (go to table 2)
- ☐ 2. Hip Exercise (go to table 3)
- ☐ 3. Back Exercise (go to table 4)
- ☐ 4. Abdomen Exercise (go to table 5)
- ☐ 5. Chest Exercise (go to table 6)
- ☐ 6. Shoulder and Arm Exercise (go to table 7)

Figure 81: Exercise Choose

4.4.3. Ideation

After exploring design options through ideation sketching (Figure 82), the concept in yellow area was chosen as a final direction. This sketch included all the users selected in the design guidelines and would meet their needs.

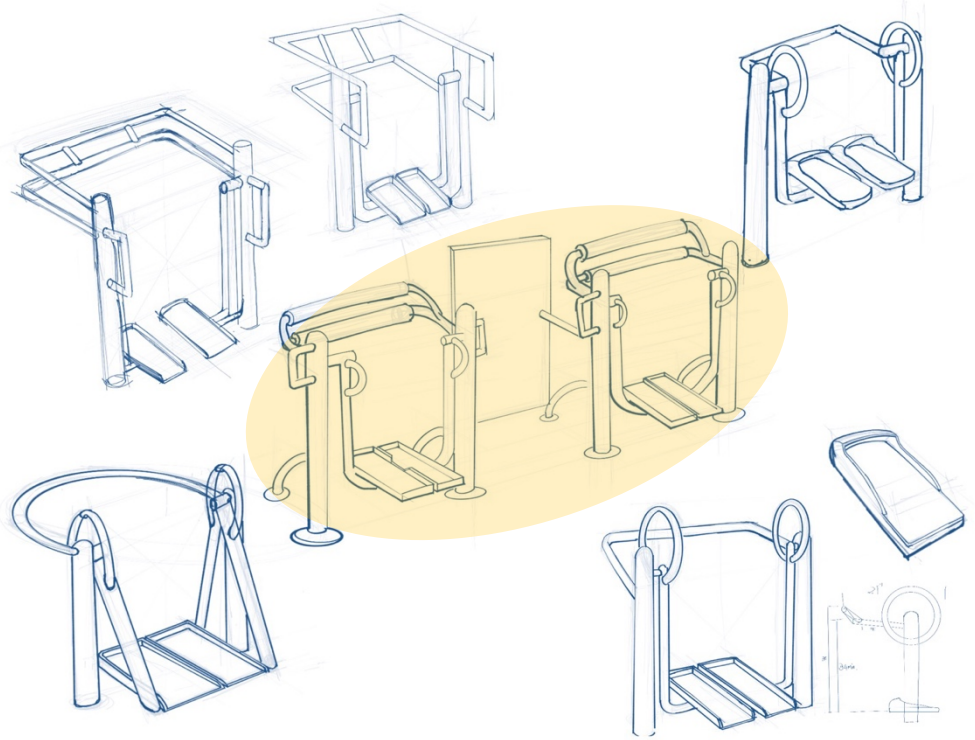


Figure 82: Air Walker Sketch (Liang 2024)

4.4.4. Making Model

I followed the design guidelines and started making the model. First, I considered the need for handrails for the elderly and then the height of the foot platform. The size of the protruding needed to be considered along with the handrails.

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

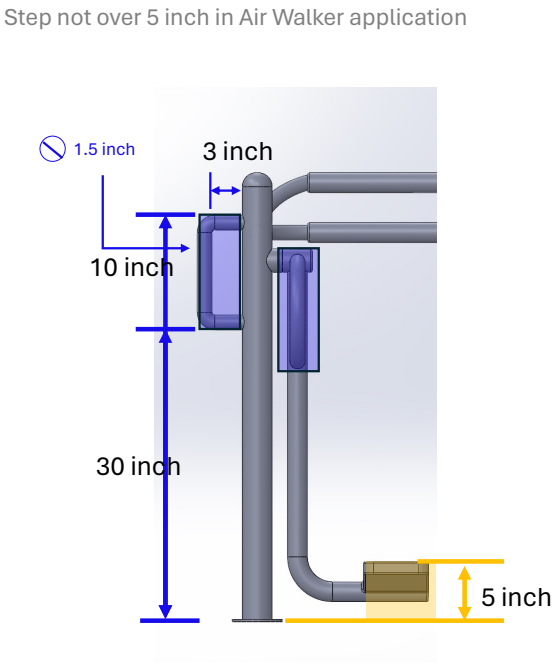


Figure 83: Handrail and Step Height

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

Protruding objects in Air Walker application

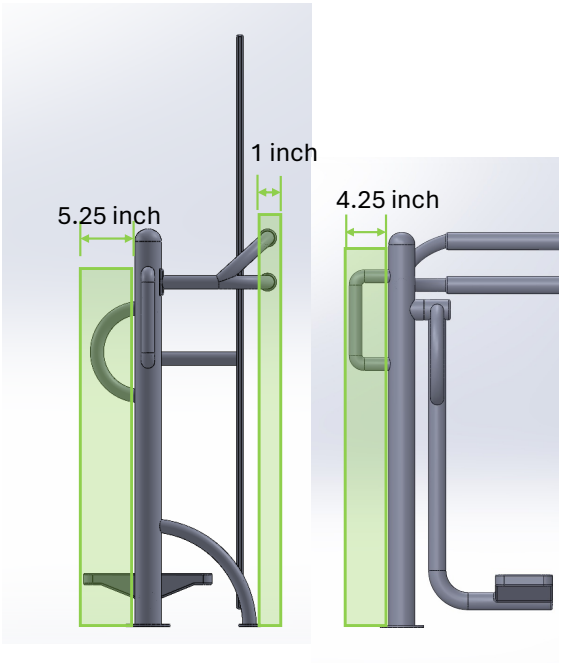


Figure 84: Protruding Objects

The second step is to consider the range of movement of the legs of an elderly person. According to the leg range of movement dimensions in the design tools, the leg rotation of the Air Walker is set at no more than 60 degrees forward and no more than 45 degrees backward.

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

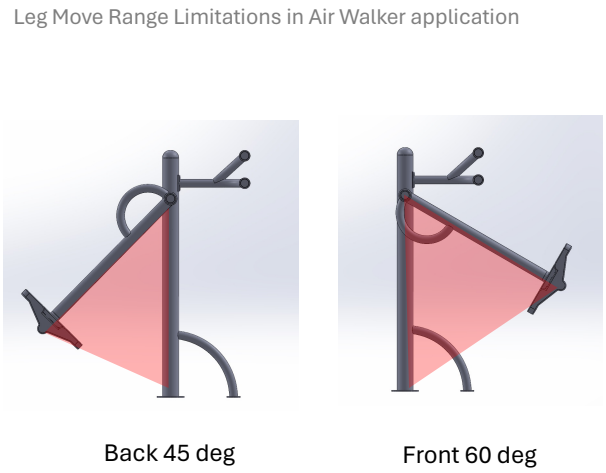


Figure 85: Leg Move Range Limitations

The third step is to design the foot platform according to the guidelines, I need to consider the size of the foot platform and non-slip. Customer groups are easy to use.

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range_ J Turn Space _K Handrail on Ramp	

Non-slip/Cover foot pedal in Air Walker application

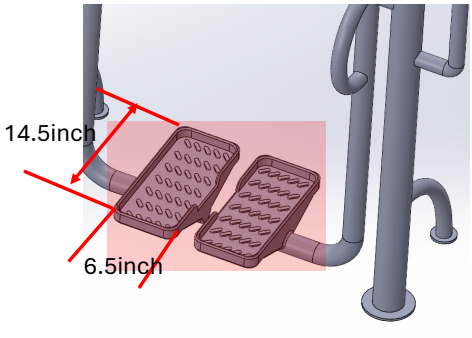


Figure 86: Non-slip Pedal Cover Foot

The fourth step, the main consideration of the product user comfort, the surface of the product needs to be smooth, in the position of the elderly handrail needs to be placed in the soft and comfortable material, so that the user group feel comfortable. And in the middle of the two Air Walkers, add the information board and leave the space for placing the assistive devices, so as to make it easy for different user groups to use.

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

Soft material in Air Walker application

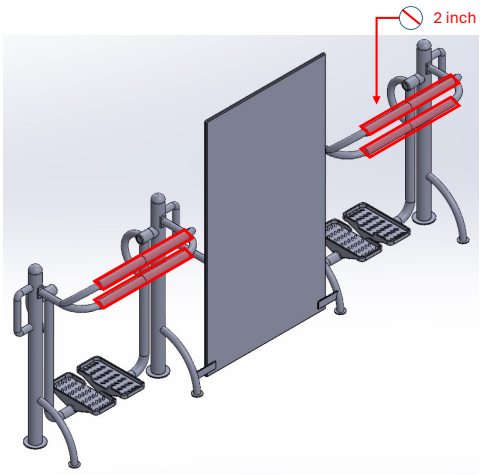


Figure 87: Soft Material

	Avoid	Consider	Standard
Elderly	Straining the Leg muscles Shear Edge/Point/Corner Step Over Height More Than 5 Inch _C Square or Angle Pipe/Part Protrusions other than equipment	Semantics Move Range Limitations _A Non-slip Pedal Cover Foot Panel Seating Dimension _B	ADA ASTM Anthropometry Ergonomic
Tactile Disorder	Rough Surface	Soft Material	
Vision Disorder	Protruding Objects _E Green, Blue, and Purple at Same Time	Sign Should Expanded(formula) _D	
Hear Disorder	Fall	Handrail _G	
Canes Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Hold the Canes	
Walker Mobility Disorder	Excessive Resistance Fall	Handrail _G Accessible Routes _F Rest Place Place to Put Walker	
Wheelchair Mobility Disorder	Falling Out Wheelchair Excessive Resistance	Handrail _G Accessible Routes _F Rest Place Place to Put Wheelchair Transfer _L Reach Range _J Turn Space _K Handrail on Ramp	

Non - Rough Surface, and Shear edge/point/Corner in Air Walker application

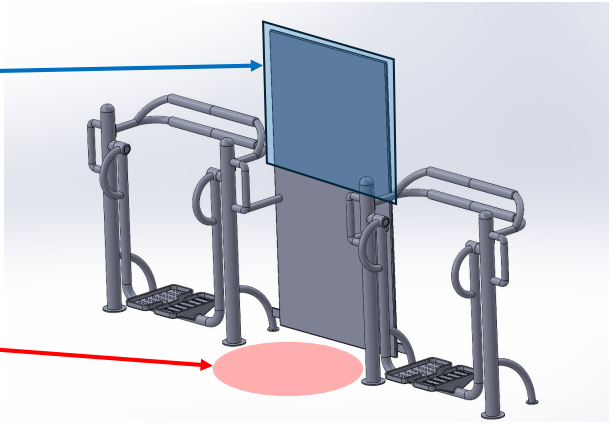


Figure 88: Information Board and Assistive devices

4.4.5. Rendering Model

In this section the main focus is to show future scenarios where the product will be used in real-life applications.

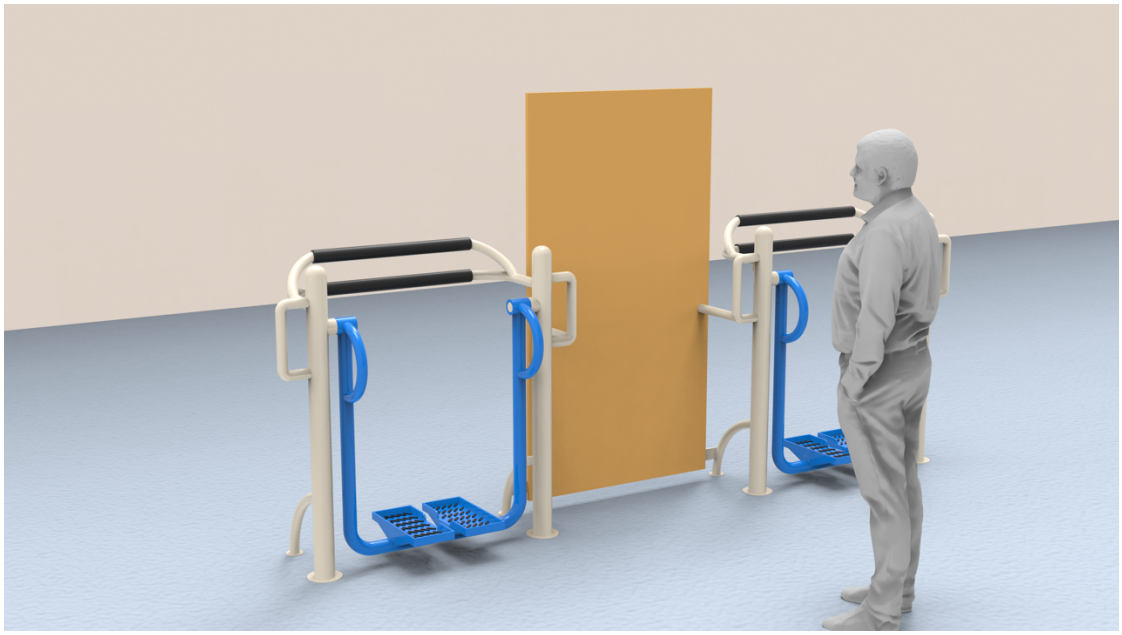


Figure 89: Rendering 1

Figure 90: Rendering 2

Chapter 5. Conclusion

5.1. Conclusion

Through research on the benefits of exercise for the physical and mental health of older persons and older persons with disabilities, this thesis has found that daily exercise, especially outdoor exercise, is necessary for older persons and older persons with disabilities. Older persons and older persons with disabilities need a minimum of 30 minutes of exercise per day and muscle-strengthening exercises at least twice a week. They also need to practice balance exercises. The main areas of focus that older adults and older adults with disabilities are leg exercises, hip exercises, back exercises, abdominal exercises, chest exercises, shoulder, and arm exercises. Therefore, in chapter 3 of the thesis, there is given relevant avoidance, considerations and individual sizes, and standards required by some governments and for the design of design of exercise equipment. Specific issues need to be analyzed.

5.2. Further Research

This thesis only discusses the guidelines of what to avoid, what to consider, some of the sizes, and some of the basic government and association requirements for exercise equipment for the elderly and elderly disabled in terms of legs, hips, backs, abdomens, chests, shoulders, and arms.

Using the guidelines as a basis, adding user populations and basic data, and turning the guidelines into a cell phone app, designers can easily and conveniently design outdoor exercise equipment that meets their target population.

Of course, more in-depth research is needed to realize the accessibility of outdoor exercise equipment for the elderly and the elderly with disabilities, and it is worthwhile to conduct in-depth

research to realize the barrier-free use of outdoor exercise equipment for the elderly and the elderly with disabilities to exercise and make them live a healthy and happy life.

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