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Exergaming: Effects on Elderly in a Smart Gym Environment

Bachelor of Sports Studies

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ABSTRACT

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Age related changes and chronic conditions affect older adult's everyday life. Physical activity is proven to delay and reduce age related symptoms and conditions in elderly. Especially balance and strength training should be targeted to help in fall prevention, since falls are the number one reason for serious injuries in older adults.
Exergames combine physical activity with games and provide mental, physical as well as social benefits for elderly. They are an innovative and fun method to reach the recommended amount of daily physical activity or to encourage and motivate sedentary people to be active.
Enjoyment and fun during the exergames is a major condition that needs to be present in all exergames.

The thesis supports the claim that exergames provide health benefits for elderly. Especially strength and balance development through exergames proves to be a viable option for fall prevention. Cognitive improvements and mental benefits in elderly were achieved with exergaming equipment.

The aim and purpose of the thesis is to present scientifically reliable information about physical activity and exergaming, that will be used to produce a product for the commissioning party. The product will be presented in a Portable Document Format (PDF), that contains exercise recommendations for elderly in the newly build smart gym. The exercises and workouts will be focused on strength and balance training for elderly. Additionally, the product will include safety information about physical activity with chronic conditions.

The research tasks of my Thesis were:

1. To find scientifically reliable information about physical activity and exergames.
2. Using scientifically reliable information to create a strength and balance program.
3. What are the major chronic conditions to consider?
4. How to build strength and balance in the smart gym?
5. Are elderly people benefiting from new technology and Exergames?

FORWARD

Games represent a new lively art, one as appropriate for the digital age as those earlier media were for the machine age. They open up new aesthetic experiences and transform the computer screen into a realm of experimentation and innovation that is broadly accessible (Jenkins 2005).

CONTENTS

1 INTRODUCTION

Older adults suffer from a variety of age related changes, the thesis analyses this target group and provides evidence that physical activity can be used to improve, delay and often prevent conditions like type 2 diabetes, stroke, arthritis, and especially falls in elderly (WHO, 2017). Physical activity can also be used to strengthen social interactions, which is as equally important for elderly to prevent depression, and isolation (Staiano & Calvert, 2011). Physical activity recommendations, effects of physical activity on the elderly as well as the most common chronic diseases are reported to provide a better understanding of exergames.

Exergames combine exercises with games, also called Active Video Games (Lieberman, 2006). The thesis provides evidence that elderly benefit from exergames by developing physical, mental and social health. The stated theory will be used to develop product for Myötätuuli, which acts as the commissioning party.

Myötätuuli is a non-profit organization, that specializes in offering physical activity services run by students, and supervised by teachers and staff. The product is a strength and balance guide for the newly build smart gym at the Kajaani University of Applied Sciences.

2 THEORETICAL BACKGROUND

This chapter describes the recommended amount of physical activity (PA) for the elderly population, and the effects of PA on this population. Furthermore, ageing, and its effects on the human body, as well as chronic conditions for elderly are analyzed. Moreover, the term Exergaming is explained, and possible health benefits of exergaming for the elderly reported. Finally, methods of how to build balance and strength in the smart gym are presented.

2.1 Physical Activity

Health is directly influenced, and strongly connected to PA, the Center for Disease Control and Prevention (CDC), reports, that PA positively affects Health, and Well-being. Examples are weight control, reduced risks for cardiovascular disease, type 2 diabetes, improved mental health, and cognitive functions. (CDC, 2015). Additionally, physical activity for elderly is a great tool for community involvement, and engagement in social activities (WHO, 2015, 70). The World Health Organization (WHO) states, that Health can be broken down to a construct, which consists of three building blocks, Physical Health, Mental Health, and Social Health as shown in Figure 1. Physical health is a term used to describe all parts that affect the body, including physical activity, nutrition, drugs, rest and sleep etc. (Department of Health, 2006).

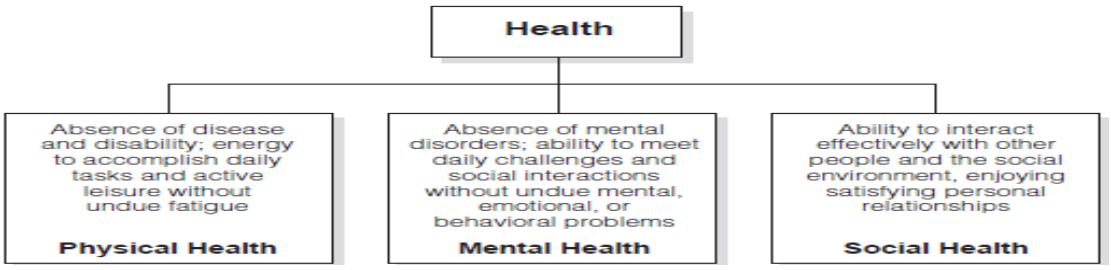


Figure 1: Nieman (2011) Exercise Testing and Prescription. *A Health-Related Approach.*

This indicates that health is more than the absence of illness, it extends to feelings, cognitive functions, as well as social connections (Nieman, 2011, 7). To sum up, physical activity is a key factor for health, Nieman expresses, that out of all age groups, the elderly population benefit the most from engaging in physical activity, and an active lifestyle (Nieman, 2011, 543). Physical activity recommendations are guidelines for individuals to help them understand the amount, volume, and intensity of needed PA. These recommendations are slightly different for each country, nevertheless, they all contribute to society's' wellbeing.

2.1.1 Physical Activity Recommendations for Elderly

Elderly people are older adults of age 65 and higher, as defined by the World Health Organization in 2001 (Kowal, 2001, 1). The CDC, and WHO both share very identical physical activity recommendations, both state, that older adults age 65 or higher should engage weekly in 150 minutes of moderate-intensity aerobic activity, or as an alternative perform 75 minutes of vigorous-intensity aerobic activity. Another option is to perform an equal mix of moderate- and vigorous intensity throughout the week. To clarify, the American College of Sports and Medicine (ACSM), and the American Heart Association (AHA) explain, what moderate or vigorous intensity activities could look like. For instance, moderate intensity PA could be walking with a normal and faster pace, cleaning, carpentry, mowing grass or dancing. These activities would represent a 5, or 6, on a scale that measures a person's physical limit from 0 to 10. On the same scale, vigorous intensity activities would represent a 7, or 8, these activities could be jogging & running, shoveling sand, heavy farming, swimming or cycling (Haskell et al. 2007, 1086).

It is recommended that aerobic activities should be done in at least ten-minute sessions, and to add muscle-strengthening exercises that include all big muscle groups twice or more each week. The biggest difference between the recommendations of the CDC, and WHO are that the World Health Organization emphasizes on physical activities that strengthens balance for elderly with a low ability to move. These exercises should be done three times a week to reduce the risk of falling of

up to 30%. If the recommended amount cannot be achieved due to “health conditions”, the individuals of this age group should aim to be as active as possible, in a way that is safe and improves the condition (WHO, 2010, 31). Additionally, five hours weekly which equals to 300 minutes of moderate-intensity aerobic activity, or 150 minutes of vigorous-intensity aerobic activity have higher health benefits. Examples of health benefits are a reduced risk for chronic diseases, or harmful weight gain (CDC, 2015, Physical Activity, Physical Activity Basics).

2.1.2 Benefits of Physical Activity for Elderly

Being active, and engaging in an active lifestyle has a direct impact on a person’s life span. For instance, an analysis of studies revealed that individuals who participated weekly in 150 minutes of moderate PA, have a 31% decreased mortality rate as compared to less active individuals. Inactivity is more widespread in older adults, that is why people of age 60 and higher have the biggest health benefits (Arem et al. 2015, 6). The Office of Disease Prevention and Health Promotion (ODPHP), supports the statement that physical activity reduces the risk of premature death. Figure 2 illustrates, that the relative risk of dying prematurely drops with an increased amount of physical activity.

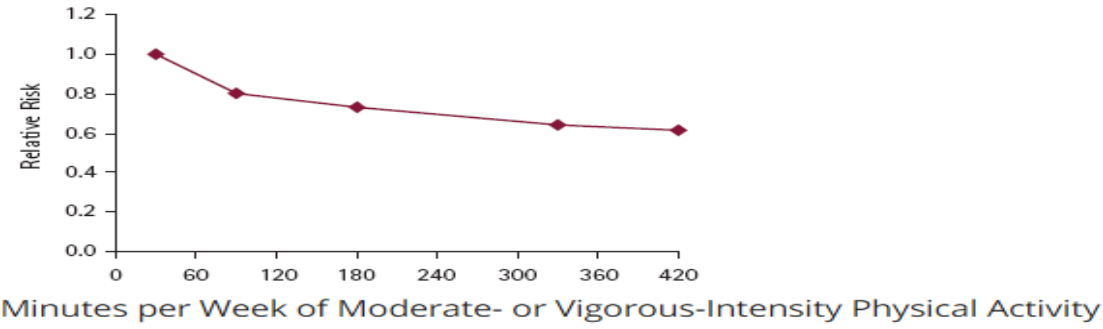


Figure 2: ODPHP (2008) *Relative Risk of Dying Prematurely.*

Other potential benefits of consistent physical activity are:

- A reduced risk of cardiovascular disease and stroke as well a reduced high blood pressure (Blair et al. 1996, 205-10; Diaz & Daichi, 2013)

- Reduced symptoms of depression and increased cognitive function (Strawbridge et al. 2002; Paterson & Warburton, 2010)
- Reduced risk for cancer and enhanced muscle mass and function (Cruz-Jentoft et al. 2014; Kushi et al. 2010)
- Reduced risk for osteoporosis, bone fractures and arthritis (Moore et al. 2016, 87-88; U.S. Department of Health and Human Services, 2004)
- Reduced risk of for diabetes and obesity as well as developing enhanced muscle mass and function (LaMonte et al. 2005; Cruz-Jentoft et al. 2014)

2.2 Ageing and Chronic Conditions

The overall life expectancy for the elderly population is constantly rising (Fig. 3). The World Health Organization estimates that by the year 2050, the global population of elderly aged 60 or higher will increase to 2 billion, compared to 900 million in 2015. The total global population for this age group will rise from 12% to 22%. Advanced age increases the risk for chronic diseases, and health limitations, this results in a growing need for health, and social care facilities (WHO, 2015, 48-50).

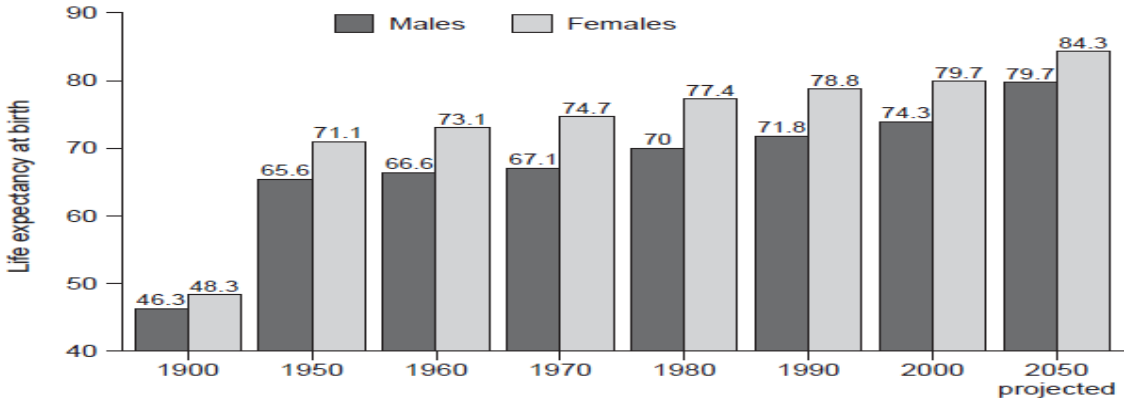


Figure 3: Nieman, D. (2010) National Center for Health Statistics. *Changes in Life Expectancy from 1900, with Projections until 2050.*

It is crucial for elderly's everyday life to be able to move around independently and safely. Mobility is a key aspect that determines if a person can continue to function

in the community (Brown & Flood 2013). The ability to physically function is affected by ageing, which limits the capability to continue an active lifestyle. The term physically functioning is used to express a person's ability to perform physical work in everyday life, be is grocery shopping or simple housework tasks (Chatterji et al. 2015, 563-570). Changes in the cardiovascular system, muscle mass and strength, respiratory system, as well as hearing and vision of the sensory nervous system influence the body's ability to function in a safe and effective way. (Strait & Lakatta 2012; Mitchell et al. 2012; Sharma & Goodwin 2006; Heine & Browning 2002)

Physical disability is a constant threat for older adults, the WHO illustrates this (Fig. 4) by defining the "Disability threshold" as not being able to carry out everyday activities and needing help from someone else. Elderly with low functional capacity are at a high risk of disability when the range of function is at, or close to the "Disability threshold" (WHO, 2002). Chronic conditions are vastly responsible for disability in older adults, the impact each condition has on the body variates depending on the disease. Musculoskeletal disorder like osteoporosis and arthritis, or cardiovascular diseases (CVD) like stroke or peripheral artery disease (PAD), have the highest disabling impact on the elderly population (Klijs et al. 2011.) In addition, cognitive decline, depression and anxiety together with dementia are health disorders, responsible for a reduced functioning capacity, and may lead to disability (WHO, 2015, 55-60).

Myötätuuli's offers physical exercises services to elderly clients with a variety of conditions. The most common illnesses and disorders in their client base are weak muscles because of advanced age, which can lead to falls and other health problems. Vision impairments are closely related with falls. Cardiovascular diseases, and diabetes are also typical conditions for Myötätuuli's clients. Therefore, it is important to educate the instructors, and tailor the physical activity classes to meet the client's needs and physical ability level.

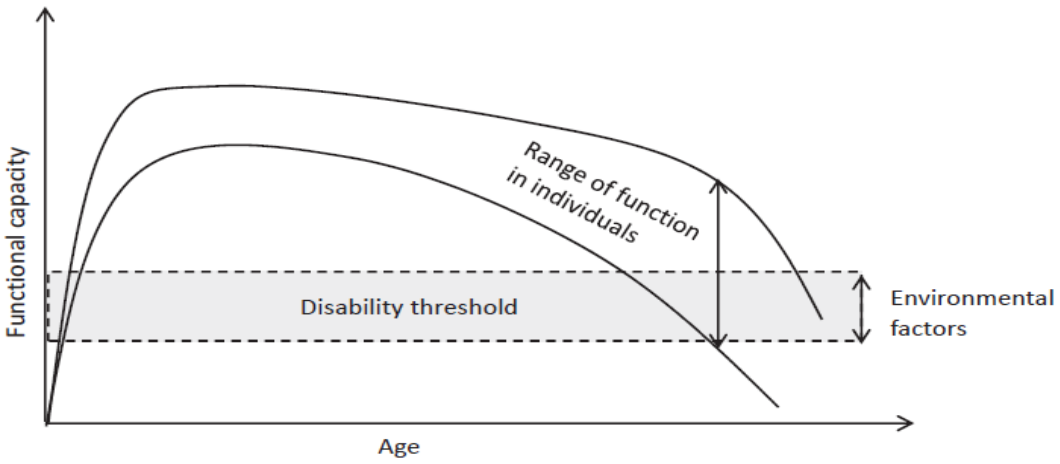


Figure 4: WHO (2002) *A Life Course Approach to Functional Capacity, Aging and Disability.*

2.2.1 Musculoskeletal Disorder

Sarcopenia, is the term used to describe the loss of muscle mass that develops with the aging process. A reduction in muscle mass, and strength increases the risk of developing mobility restrictions. A decrease in leg strength may lead to falls, the consequences of sarcopenia compromises the ability to function independently. Older adults of age 75 and above, loose approximately 3-4% of muscle strength yearly. However, an active lifestyle and strength training program throughout lifetime delays, and reduces the loss of muscle mass and strength (Nieman, 2011, 547-48.) Other scientific literature further adds that sarcopenia is not only caused by the aging, but also that “fat gain and inadequate intake of dietary energy and protein” can be the primary reasons that causes elderly to lose muscle mass and become frail (Roubenoff 2000, 1).

A five-year long study of 3,069 men and 589 women by Brill et al. reports, that the chance of developing functional limitations decreases with increased strength levels. As illustrated in Figure 5, men and women with high strength, had a lower prevalence of developing functional limitations as compared to low strength (Brill et al. 2000). Increased strength levels, muscle mass, and power are benefits of resistance training that can counter age related muscle and strength loss in frail elderly (Nelson et al. 2007).

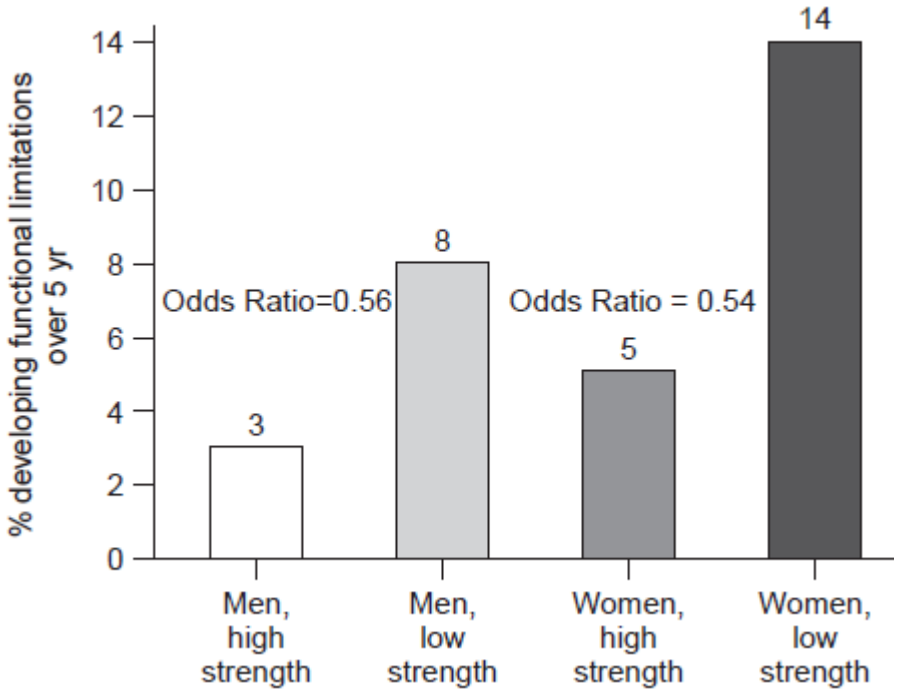


Figure 5: Brill et al. (2011*) Muscular Strength and Physical Function.*

Osteoporosis, is a disease where the density and mass of bones decreases over time, increasing the risk of hip, wrist, and vertebral fractures. Appendix 2, illustrates a comparison between a normal and osteoporotic bone, as well as highlighting the three most common areas of osteoporosis. Osteoporosis can occur at any age, but is more likely to appear in older adults of age 45 and above. Physical activity, especially weight training proves to be a successful tool to maintain and develop bone density across all ages. Thus, reducing the risk of bone fractures, as well as reducing the risk of falls, and fall related injuries (Nieman, 2011, 550-60.) A cross sectional study by Todd & Robinson (2018), showed that “high impact” exercises are more beneficial in increasing the bone mineral density. People with osteoporosis need to be encouraged to engage in activities like plyometrics, which stands for jumping exercises, jogging, or running. The study further adds that a sufficient calcium consumption, avoidance of alcohol and smoking as well as maintaining a normal bodyweight can help to reduce the stress of osteoporosis (Todd & Robinson 2018, 322).

Arthritis, is a chronic condition that is responsible for joint inflammation and is a term used to describe a variety of rheumatic diseases. These diseases affect joints and muscles, causing pain and stiffness that restrict mobility, and limit everyday activities of elderly. Osteoarthritis is the most prevalent type of arthritis, it occurs when the protective cartilage layer between two joints starts to break down, see appendix 3. The risk of arthritis increases with age; however, the chance of developing arthritis is higher in overweight and obese people. As mentioned above, elderly with arthritis are likely to be in pain and suffer from a restricted range of motion, therefore it is crucial to adjust the training exercises to provide joint protection. Physical activity for elderly with arthritis, should be focused on improving the range of motion, mobility, muscle strength as well as endurance type of training (Nieman, 2011, 560-67.) Sports medicine literature supports Nieman's description of Arthritis, but further notes, that physical exercises improves "joint health" and that arthritis not only affects the joints, but also the overall wellbeing and can cause an increased risk for cardiovascular disease. The study further reports that most people with arthritis engage in a sedentary lifestyle, with lack of physical exercise that can lead to other chronic illnesses (van Zanten et al. 2015, 140).

2.2.2 Falls

The risk of falls is especially high in the elderly audience, nearly 28–35% of elderly aged over 65 experience injuries due to falls. Typical examples of injuries are bruises, sprains, broken bones, hip fractures, and serious falls that can be life threatening and cause death. Victims of falls experience depression, loss of independence and confusion. This limits possible everyday activities to a minimum, leading to further physio motor and cognitive decay. The likelihood of falls and the severity of injuries increases with age, reaching its peak at the age of 85 and beyond for both men and women. Possible risk factors for falls in older people are illustrated in appendix 1. The most common risk factors for falls, include loss of muscle strength, balance impairments, mobility limitations due to chronic conditions, visual decline, and usage of various medications. These risk factors are important to improve for elderly people, and should be focused on during physical activity lessons and exercises. Furthermore, environmental risk factors such as

faulty floors, or poor lightning conditions are also major risks for elderly and can lead to falls (WHO, 2007, 1-6.) Problems with vision in the elderly population is mostly due to age related changes in the eye, the official term for this condition is age-related macular degeneration (AMD), and affects 5% of elderly aged 75 and above (Gehrs et al. 2010, 1).

Balance is defined as “a generic term describing the dynamics of body posture to prevent falling. It is related to the inertial forces acting on the body and the inertial characteristics of body segments” (Winter, 1995). According to Frank and Patla (2003), balance issues in elderly are often not detected prior to falls. Therefore, elderly that engage in health-enhancing exercises and physical activity, report a reduced risk of falls and mobility restrictions (Nelson et al. 2007). Strength and balance training over a long-lasting period, combined with walking shows to be effective in reducing falls and preventing injuries in elderly people (Campbell et al. 1999). Sherrington emphasizes, that physio motor exercises, strength training together with activities like “tai chi, dancing, and walking” can enhance balance and reduce falls in elderly (Sherrington et al. 2008, 8).

However, it is crucial to determine the reason for balance impairments for everyone. In case of muscle weakness and physio motor deterioration, exercise programs need to be altered and focus on weight training. If the sensory system is the biggest reason for balance problems, it is recommended to include exercises that focus on environmental stimulation by changing the lightning, terrain or include obstacles to make the exercises more challenging (Sherrington et al. 2008, 7-9.)

2.2.3 Diabetes Mellitus

Diabetes Mellitus or Diabetes, is a disease where a defect in the insulin production causes high amounts of blood sugar also called glucose, or the body is not able to use the insulin to break down sugar. Insulin is needed to break down the glucose, otherwise it piles up and disposed of into the urine. If the body is not able to

produce insulin, and the person is dependent on daily insulin injections, he is diagnosed with type 1 diabetes. Symptoms of type 1 diabetes are strong urination needs, excessive thirst, steady hunger, loss of bodyweight, lesser vision and physical weakness (IDF, 2017, 84-87.)

If the person's body can produce insulin, but the amount is not enough or the body's cells are resistant to it, then the person is diagnosed with type 2 diabetes which accounts for up to 90% of all diabetes cases, and elderly aged 65 or higher have the highest risk of developing diabetes (IDF ,2017, 16-19). It is estimated that nearly 85% of people with type 2 diabetes, are overweight or obese, the risk of being diagnosed with type 2 diabetes increases with higher obesity level. (Nieman, 2011, 436). Preventing or at least delaying type 2 diabetes is achievable through constant physical activity, a healthy diet, keeping normal bodyweight and preventing tobacco usage (WHO, 2017). The symptoms of type 2 diabetes are identical to those of type 1 diabetes, but are mostly barely notable. The International Diabetes Federation (IDF) reports, that diabetes is a major cause for "blindness, kidney failure and lower-limb amputation," as well as dental disease and complications of pregnancy. Furthermore, diabetes increases the likelihood two to three times of developing cardiovascular diseases, as compared to diabetes free people (IDF, 2017, 84-87.)

2.2.4 Cardiovascular Disease

Cardiovascular diseases affect the heart and the heart's blood vessels. It is important to note that CVD is not a single disease, but a name for over twenty different disorders of the heart. The American Heart Association (2008) notes, that if all leading CVD were erased, the overall life expectancy would increase by almost seven years, in comparison to cancer where the growth would only amount to three years. The World Health Organization reports, that CVDs are globally the number one reason of death. The total number of cardiovascular diseases in 2015 was estimated to be around 17.7 million, this number represents 31% of all deaths globally. Risk factors for developing CVDs are wrong diet, physical inactivity, smoking and unhealthy usage of alcohol. (WHO, 2017).

The biggest cause for CVD is the accumulation of “fatty, plague material in the inner layer of blood vessels”, named “Atherosclerosis”, this can lead to a heart attack, also referred to as coronary heart disease. As stated by WHO, out of the 17.7 million deaths to CVDs, coronary heart disease was the responsible cause for 7.4 million deceases (WHO, 2017). Atherosclerosis can also cause a stroke; a stroke occurs when blood vessels in the brain are blocked, a total of 6.7 million deaths were caused by stroke in 2015 (WHO, 2017).

Peripheral artery disease (PAD) which affects the legs, arms, stomach or kidneys are another cause of atherosclerosis (Nieman, 2011, 299-303.) PAD is dangerous, if left untreated it can lead to dying body tissue and cause amputation of body parts, or cause a stroke. Typical symptoms for elderly are bad blood circulation in legs, which can lead to cramping but also causes discomfort and pain (American Heart Association, 2015).

The stroke is another form of CVD where nutrients and oxygen are cut off from the brain, without oxygen the nerve cells stop to function and begin dying. People with high blood pressure have a 70% increased chance that a stroke occurs, other risks worth mentioning are smoking, obesity, excessive alcohol consumption, diabetes and physical inactivity (Nieman, 2011, 306). Moderate physical activity reduces the risk for stroke by 11-15% and vigorous physical activity by 19-22% (Diep et al. 2010).

2.3 Exergames

Exergame is a combination word from “exercising” and “game”, also known as Active Video Game (AVG), (Lieberman, 2006), and is defined as “a form of digital gaming requiring aerobic physical effort – exceeding sedentary activity level and including strength-, balance-, or flexibility-related activity – from the player that determines the outcome of the game” (Kari & Makkonen, 2014, 2).

2.3.1 Exergame Equipment and History

Exergaming equipment and products are becoming more popular, they can be used in apartments and homes, fitness and senior centers, rehabilitation centers and activity-amusement parks. Another advantage is that exergames can be modified to function for elderly with disabilities, cognitive impairments or “rehabilitation needs”. It is possible to design games that can give instructions to deaf people in form of sign language or other methods that would be beneficial for this type of group (Peng et al. 2012.)

The essence of exergames roots back to the 1970s – 1980s, where arcade games like Pac Man were played in an upright position and required more body effort from the players compared to modern video games played on the couch. One of the most popular exergames released in 1998 was the “Dance Dance Revolution” rhythm game, the game was played on a pad that was equipped with “touch-sensitive” sensors (Bogost, 2005.)

2.3.2 Exergame Technology and Importance of Fun

There are three different kinds of exergames, first the so called “screen-based games”, played at home on game consoles. Second, games on mobile phones, and finally, “light-sensor-based” games that record motion via infrared, cameras or “pressure sensors” (Lieberman et al., 2011). Exergames with motion-sensors are advantageous because they allow the player to interact directly with the game,

eliminating the need to focus on any controller and simplifying the synergy between the player and the game (Gerling et al. 2012). The success of exergaming programs for elderly depends on the acceptance of new technologies by this age group. Literature about elderly's mindset regarding the acceptance of new technology to increase physical activity is diverse.

Nevertheless, there is evidence that elderly find exergames to be attractive and enjoyable, a study by Bird et al. (2015), finds that enjoyment and fun during the exergames is directly connected to enhanced wellbeing. The study further reports that "enjoyment" is a major aspect for exergame sessions. Elderly that find physical exercises to be fun and enjoyable tend to be more active and engage in physical activity's more often and for a longer extent of time. It is important to note that the social aspect of being together with friends or in a group contributed heavily to the enjoyment factor. Exergames, where people challenged themselves or compared scores with others and had fun in a group environment not only improved the physical condition of the players, but also can be used as a tool against "social isolation" (Bird et al. 2015, 1-6.)

2.3.3 Risks of Exergames

However, because of doubt about approaching new technologies, elderly's can develop a negative attitude towards exergames, and become anxious about making mistakes (Neufeldt, 2009, 54-55). Another risk factor are group-based exergames, it is possible that elderly with chronic conditions, overweight or obese individuals, feel ashamed about exercising in front of audience, and are therefore refusing to participate (Peng et al. 2012, 19).

Therefore, it is important to develop games which are appropriate for elderly people by taking the needs and concerns into account, and incorporate them into a final product (De Schutter & Vandenabeele, 2008). Most available exergames do not meet these criteria's and are therefore not advisable for elderly. A study by Planinc et al. (2013) states, that design guidelines for exergames are a helpful tool for game developers to create suitable games for the elderly community.

2.4 Effects of Exergaming on Elderly Population

Preserving the ability to physically function with or without disabilities is a major concern for the elderly population. Technological progress in form of exergames shows promising capabilities to strengthen motor function, as well as cognitive functions to support elderly in their daily activities (Lange et al. 2010, 340.)

Krause and Benavidez (2014) outline, that exergames caused videogaming to be considered as a possible stimulant for increasing physical activity and assisting in reaching the recommended amount of daily PA, as well as encourage and motivate sedentary people to be active by allowing active play. In addition, exergames can boost the physical activity level of players without the requirement of knowledge on physical exercise (Bogost, 2005). Furthermore, Trout and Christie (2007) emphasize, that exergames can encourage people's motivation regarding different types of physical activity and therefore act as an impulse to be more active. Exergames can be considered a supplementary element to increase overall health and physical fitness, or as a different approach to regular physical activity, modern gym equipment such as treadmills or exercise bikes are rigged with a screen and computer, allowing the player to travel virtually.

2.4.1 Cognitive Stimulation

Especially elderly people can benefit a lot from virtual reality, granting the player the ability to visit a variety of places in a virtual environment that would be normally too dangerous, too far away or because of health-related problems not possible. (Nurkkala, 2014, 408-409.) Virtual reality is "an immersive and interactive system that provides users with the illusion of entering a virtual world" (Heim, 1998).

A study by Anderson-Hanley et al. states, that the number of dementia conditions could approach "100 million by 2050" and that exergames provide cognitive improvement by combining physical exercise with virtual reality. The study concluded, that elderly who engaged in "cybercycling" had higher cognitive benefits

compared to older adults who participated in regular physical exercise. Maneuvering through a three-dimensional landscape, expecting turns and challenge themselves against others, demands extra focus and increased decision making, resulting in higher cognitive stimulation (Anderson-Hanley et al. 2012, 7-9.) Monteiro-Junior et al. (2016) emphasizes, that the need to carry out dual tasks at the same time in virtual reality, contributes to cognitive and physical stimulation. This supports the statement that exergames improve cognitive functions of elderly (p. 202).

2.4.2 Fall Prevention and Exergames

A major threat to functional independency are falls, exergames offer a viable method to strengthen balance in elderly to prevent injuries, which could lead to physical impairments (Garcia et al. 2012, 51). Exergames that utilize video recording technology, and motion sensors can provide challenging balance exercises for elderly by implementing games, that demand challenging positions, and movement actions from the player (Lange et al. 2010, 346). Similarly, balance platforms equipped with sensors can detect physical force, and visualize balance performance by providing live feedback about posture control, and weight shifting of elderly (Kosse et al. 2011, 400).

The study of Kosse et al. finds, that a six- week long exercise plan of playing exergames on a dynamic balance platform, was successful in improving “functional balance due to an intervention using visual feedback on postural control”. Postural control defines the person’s ability to maintain upright position during movement, standing or sitting (Kosse et al. 2011, 402-405).

A similar research by Stanmore and Meekes (2017) reports, that older people who participated in a six-week long exercise program with exergames that were specially designed for fall prevention, and equipped with camera movement tracking systems, could reduce the risk of falls by enhancing overall balance, postural control, physical strength as well as improvements in motor functions (Stanmore & Meekes, 2017, 1-7).

Another research by Walker et al. states, that a virtual reality treadmill training program (Fig. 6), where “post stroke” patients who completed twelve training workouts over a duration of four to six weeks, produced improvements in balance, walking speed, and maximum duration of walking capabilities (2010, 115-119).

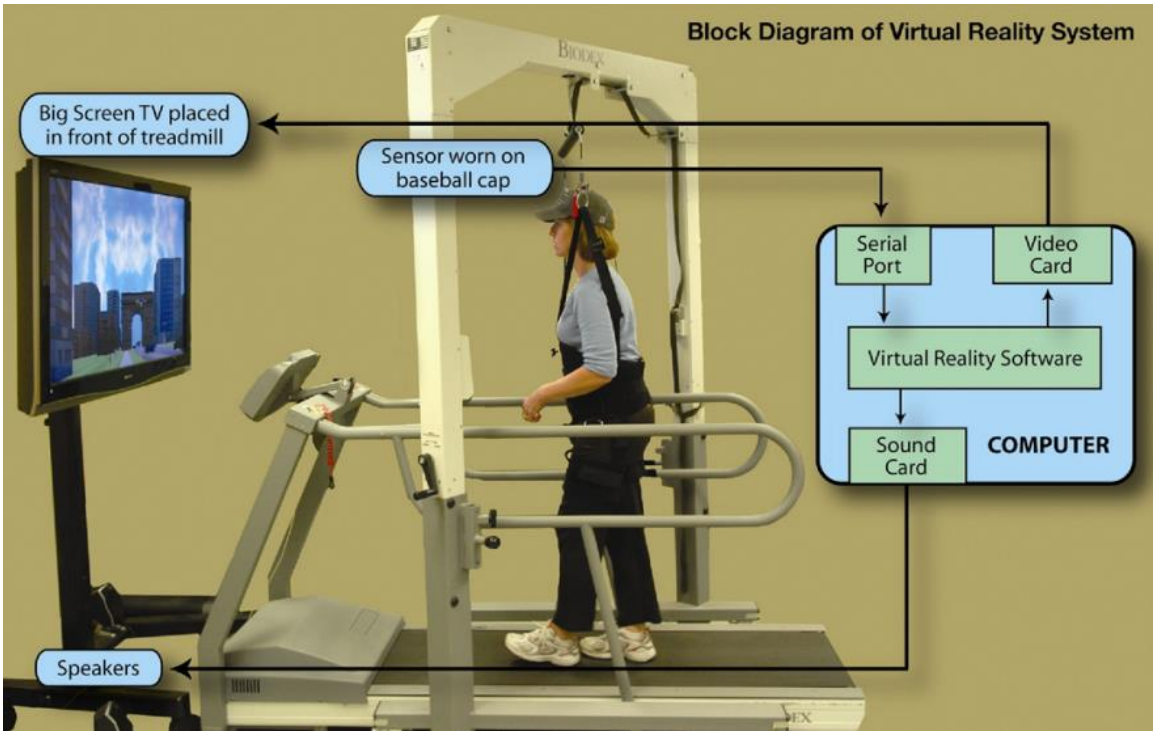


Figure 6: Walker et al. (2010) *Picture and diagram of virtual reality system with partial body weight–supported treadmill training.*

Other forms of possible exergames to improve strength and balance in the elderly audience were researched by Sato et al. (2015). The study analyzed the effectiveness of motion-sensor and camera based exergames on muscle strength and balance in 57 healthy older adults. The players interact directly with the game, no additional controller was needed, body movement and actions were necessary to interact with the game.

A total of four different exergames were tested, the first game (Fig. 7a) was an apple picking game, demanding the player to pick apples with both arms. The second game (Fig. 7b) involved balance and coordination, the players had to balance along a narrow path and simultaneously grab round objects, this game was a dual task and provided cognitive and physical stimulation. Game four (Fig. 7c) motivated players to burst balloons with their buttocks, requiring a squat like motion

that required more strength than the previous games. The final game (Fig. 7d) encouraged players to stand on one leg, the goal was to burst objects with the knee by lifting it, the game challenged the players strength, balance and coordination abilities. The results of the training program were increased motor functions, walking and balance abilities in older adults (Sato et al. 2015, 161-166.)

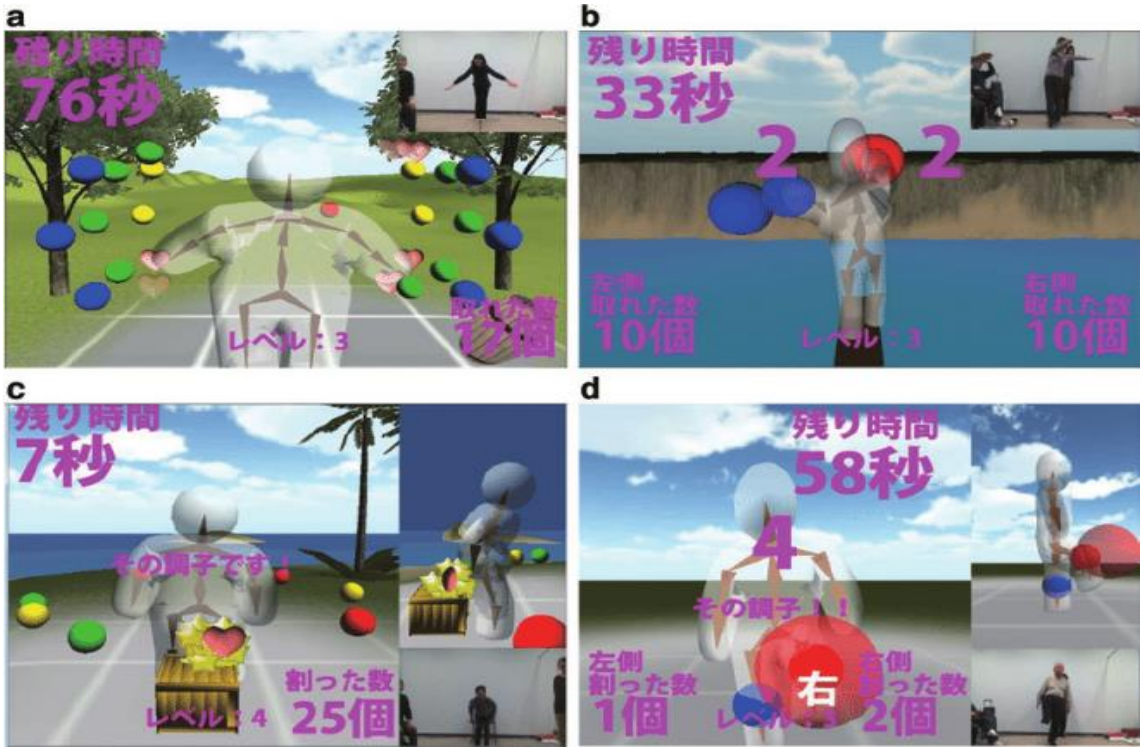


Figure 7: Sato et al. (2015) *Exergame: (a) apple game, (b) tightrope standing game, (c) balloon popping game, (d) one leg standing game*.

2.5 Design Guidelines for Exergames

Game design guidelines are described, to help Myötätuuli understand what suitable exergames for the elderly population are, and to help with future purchase decisions with available exergames on the market.

1) Physical fitness:

Keeping the physical fitness of elderly in mind is an essential element that exergames for elderly should recognize. Age-related diseases, and decline in overall health, and wellbeing together with limitations in mobility, and cognitive functions determine the players ability to play the game and need to be considered to prevent injuries. Moreover, it should be possible to play the games in a sitting or upright position because of age related changes in the musculoskeletal system that forces elderly to be in a wheelchair, or because of balance problems where breaks are a necessity. In addition, games with motion sensors should avoid “high precision gesture recognition” but rather allow a wider range of motion acceptance (Planinc et al. 2013, 59-60.)

2) Body movement:

Games require a variety of different body movements and actions to control the game, or interact with the settings, therefore players should be allowed to practice the movements in tutorials to get acquainted with the technology and feel comfortable with it. Experienced players should be able to skip the tutorial, however, now and then the game should provide a reminder of the movements to help individuals with cognitive limitations (Planinc et al. 2013, 60.)

3) Visual condition:

Age related changes affect the visual system as mentioned in Chapter 2.2.2, hence games with fast moving objects and small interfaces can cause uneasiness and panic and are therefore not suitable for elderly with visual issues. The game design guidelines recommend big icons and characters and focus on making the tasks clear and easy to understand (Planinc et al. 2013, 60.)

4) Feedback:

Ijsselsteijn et al. (2007,) states, that the present age group of elderly does not have the same understanding of technology as today's youth, this can lead to anxiety. To prevent anxiety from developing, exergames should implement visual and auditory feedback systems in the game. The type of feedback plays an important part, elderly tend to blame themselves if mistakes happen or if sudden complications occur (Gerling et al, 2012). For that reason, negative feedback should be avoided, elderly benefit the most from positive feedback that helps them to connect with the game (Planinc et al. 2013, 60.)

5) Difficulty setting:

Physical motor skills as well as cognitive abilities vary within senior citizens, exergames should grant players the chance to regulate the difficulty and adjust them according to their personal fitness level. As a result, long term motivation will be strengthened because the game provides a challenge, however, the challenge should not leave the players frustrated, the goal of the game should be attainable and fun to reach. An example of how to change the difficulty of a game is to provide random components, this forces players to act differently each time they play (Planinc et al. 2013, 60.)

6) User-friendly interface:

As mentioned above, elderly people have a low perception of technology and games, therefore it is of utmost importance to design user-friendly interfaces that are clear and easy to understand. Elderly players should be able to interact with the game without help and support from others, so that the exercise becomes the main center of attraction. Similarly, all unnecessary information should be excluded from the interface screen, minimizing the possibility of confusion (Planinc et al. 2013, 60.)

7) Topic selection:

A study by Nap et al. (2009) found, that elderly reject violence and disturbing content in games, it is therefore advantageous to design games with topics that of interest for this age group. Games that offer educational or cultural content are more likely to engage elderly in exergaming. So, called “real-world” topics like gardening or animals are one example of suitable topics. (Planinc et al. 2013, 60.)

8) Social health

Maintaining or building relationships, interacting with other people and being part of the community becomes increasingly difficult with advanced age (Gamberini et al. 2008). Participating in exergames allows elderly to interact with each other, having conversations about the game and everyday life increases the motivation for exergaming, and cultivates social interactions among the group and with their grandchildren. Developing the social health of elderly may impact the cognitive health and can help to reduce anxiety and depression (Planinc et al. 2013, 60).

Exergames that follow the above-mentioned design guidelines poses all essential features to help elderly players reach the “flow-state”. Csikszentmihalyi (1990) describes the “flow-state” as a state when players are completely absorbed in the game, the players mind is not focused on the demanding exercise but rather on the enjoyment of the game, detached from all distractions.

A study by Huberty et al., makes clear, that exercise loyalty and devotion to a program is an important obstacle to beat. Keeping up motivation and commitment for elderly with lasting chronic conditions are necessary for functional development and progress. Self-esteem, motivation, and joy are essential to achieve long-lasting exercise commitment for elderly, emphasizing the significance of suitable exergames (Huberty et al. 2008, 1-2)

3 RESEARCH PROBLEMS/- TASKS AND GUIDE CONTENT

The first and most important research task was to find scientifically reliable information about physical activity and exergames. Secondly to use this information to help create a strength and balance guide in the smart gym for Myötätuuli. The third research task was to find information about major chronic conditions, this knowledge was used in the guide to help students of Myötätuuli by providing an overview of common illnesses. The fourth research task was to find out how exergames build and improve strength and balance, this is closely connected to the final research task by providing evidence that elderly people benefit from exergames, both physically and mentally.

The guide was designed in a logical order, it starts by introducing the goal of the guide, for whom it is designed and how to use it. The introduction continues by displaying the collected information about strength and balance, exergaming, and chronic conditions. The main reason to include the mentioned information is because Myötätuuli is functioning as a learning environment for students, and students can use it to educate themselves and others.

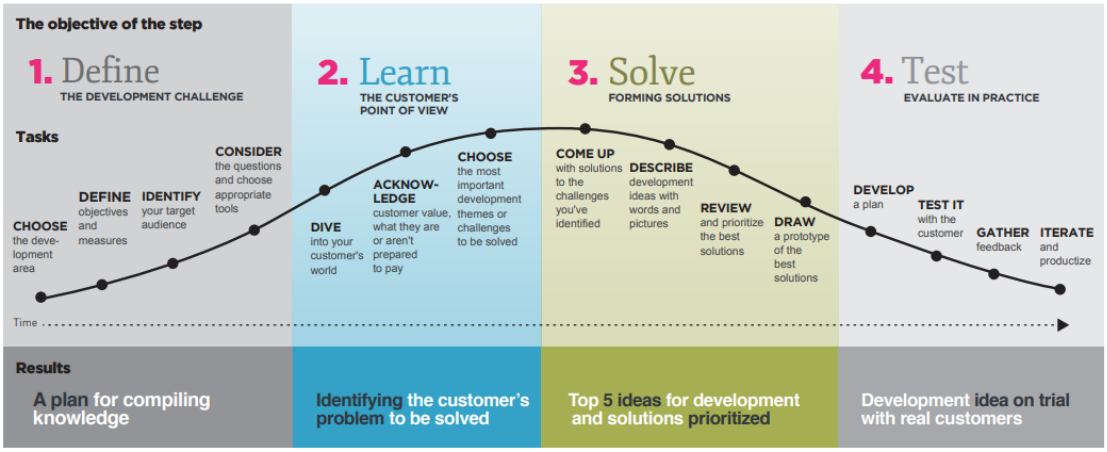
The guide's purpose was not only to provide information for students, but also to design a finished exercise program in the smart gym that Myötätuuli can immediately use to present a strength and balance service for their elderly clients. For that reason, the second part of the guide featured scientific reliable information about the overall program, and lesson duration as well as a recommended group size.

The third part of the guide introduced the available exergame equipment present in the smart gym. Each exergame equipment together with their different game variations was mentioned, and information about the physical and cognitive benefits they provide explained. As a result, it became clear that almost all exergames in the smart gym mainly provided balance and cognitive benefits, and little strength gains. This conclusion was of high importance, because it determined how the free space in the smart gym will be used. Primarily strength exercises, together with mobility and flexibility stretches are the optimal choice.

Part 4 of the guide featured a basic breakdown of a sixty-minute physical activity lesson in the smart gym. The information for this part was used from the scientifically reliable information mentioned in the second part of the guide, and presented in a compact form. Part 4 mainly focused around the warm-up and stretching of upper and lower body as well as lower body strength training for elderly. Reliable information about upper and lower body stretching and strength training exercises was used, every exercise was visualized with pictures. The pictures were taken by myself to prevent copyright issues. The fifth and final part was added as extra information to help Myötätuuli with future exergame purchase decisions.

4 RESEARCH PROCESS/PRODUCTION PROCESS

Theory about the Production Process was used to help and offer guidance. Picture 8 reports a Service Design Toolkit developed by the JAMK University of Applied Sciences.



Picture 8: JAMK University of Applied Sciences. (2012) Service Design Toolkit.

The toolkit follows a straight order, first to define the topic and identify the target group and to consider any needed tools or equipment. The topic selection and target group have been identified during the development of the thesis plan. The focus group for the thesis as well as the guide were elderly people. The main reason to choose this target group was because of my existing experience and knowledge about elderly. I wanted to make use of the experience I gained from my first practical training in Myötätuuli, where I mainly worked with older adults.

The second step was to learn about my target group, especially about their needs. Scientific reliable information was used to learn about elderly, the material for the thesis and guide were acquired by using primarily online libraries and search engines like Theseus, SPORTDiscus, and Google Scholar. Local libraries did not provide reliable and usable information about exergaming, the main reason for this is because the topic is relatively new.

The third step was to find solutions to any potential problems that I encountered. In my case, I needed to find answers to my research tasks-questions. Especially

how to develop balance and strength in the smart gym. Reviewing and prioritizing the best exercises and developing a prototype was mentioned in the service design toolkit. This helped me to think about what type of exercises I should choose and which one I should focus on. Based on that I decided to focus primarily and mobility and strength exercise for the lower body, because they are the effective to prevent falls.

The final step was testing and evaluation. The toolkit suggests testing the product with customers and to gather feedback. I strongly agree that this is an important step to improve the product and to ensure its reliability. Unfortunately, I was not able to implement this step because of wrong time management as mentioned in the conclusion in chapter 5.

The reliability of the thesis and guide will be improved by using reliable scientific information and sources. Furthermore, correct citing and avoiding plagiarism contributes to the reliability. The use of pictures is another reliability concern, pictures used in the thesis are cited and referenced in scientific manner. As previously mentioned, the pictures used in the guide were taken by myself and only showcase me to prevent copyright issues and further strengthen the reliability.

The qualitative research method will be used to analyze the material. The reason for this is because I am seeking answers to questions, it provides insight in people's experience, emotions, beliefs and relationships. Furthermore, the qualitative research methods allow for a textual question format, while the quantitative research method uses numerical values (Addo & Eboh, 2014).

The production of the guide included myself and Pakkala-Juntunen Sanna from Myötätuuli. Sanna provided small feedback about the guide. The successfulness of the cooperation between the commissioning party and me will be discussed in the Conclusion.

4.1 Development Process

The production and development process started during the R&D during September-October 2016. The course started with the topic selection and the presentation of a preliminary thesis plan. The topic “Exergaming” was chosen because of my interest in technology, games and physical activity and I wanted to combine this passion with a target group I was familiar. That is why I chose the topic “Exergaming: Effects on Elderly in a Smart Gym Environment”. Myötätuuli was a convenient choice to act as the commissioning party because I was familiar and already had experience with this organization. The benefit for Myötätuuli was that I will provide a product that they need, the smart gym was still under construction and exergames were a new topic for Myötätuuli.

The Thesis plan was presented on Tuesday the 17th of January 2017. The task was to present scientifically reliable information about my thesis topic. The thesis plan helped in deciding the research tasks and objectives for both the guide and the thesis. The feedback from the supervisor and the student peer helped in developing the thesis further.

My supervisor teacher frequently asked about my thesis process and if I need any help or guidance, this was really reassuring and I was able to send the complete Theory of my thesis on the 20th of February 2018. The first feedback session with my supervisor was held on the 20th of March 2018, this helped me to make the necessary changes and completed the theory part of my thesis. With the theory complete, I could concentrate in developing and finishing the product for Myötätuuli. The production of the thesis and guide started in March 2017 and continued all the way until May 2018.

5 CONCLUSION/ASSESSMENT

The thesis and guide met and fulfilled my overall objectives and research tasks which will be discussed in this chapter. However, many improvements could have been made to ensure a better success and reliability.

5.1 Research Tasks

The first and second research task was to find scientifically reliable information about physical activity and exergames that can be used to develop a guide for Myötätuuli. I have found many reliable sources and information that was presented in the thesis to help with the production process of the guide. However, I noticed during the development of the guide, that I lacked information about physical activity exercises that develop strength and balance in the smart gym. I needed to find more scientific reliable information that was not covered in the thesis, for example what type of stretches for elderly and what type of strength exercises are recommended. This type of information should have been present in the thesis before I started the product development, and therefore not completely fulfills the fourth research task, which was to find answers on how to build strength and balance in the smart gym?

The third research task was to find information about major chronic conditions. I have covered most of the chronic conditions and used this information in the thesis and the guide. However, more information about respiratory diseases like Asthma should have been presented, because one of Myötätuuli's client groups belong to the respiratory society.

My last research task was to answer the question if elderly people are benefiting from new technology and Exergames? Throughout the thesis and guide production process I have answered this question by relying on a variety of scientific reliable information. Elderly benefit a lot physically and mentally by engaging in exergames activity lessons.

5.2 Reliability

The successfulness and reliability of the thesis and product could have been improved more by working closer and more often with my supervising teacher and the commissioning party. Furthermore, the prolonged time to finish both the thesis and guide had a negative impact. I underestimated the overall time management and difficulty of the whole thesis process, which led to long breaks due to unforeseen circumstances.

Furthermore, the small timeframe allowed for only small feedback from the commissioning party which further decreases the reliability and successfulness. Another factor to consider is the new home location and increased distance to the university and commissioning party, this prevented me from gathering more feedback. After the move, I noticed that I lost all my social contacts, this was slightly depressing and influenced the whole thesis process.

The feedback from the commissioning party was that the guide has too much written text. It is hard to follow the presented theory because the individual slides are too full. “Less is better” was the main catch phrase. Based on the feedback, changes to the guide layout and design have taken place to fit Myötätuuli’s needs. The second concern of Myötätuuli was if a pdf document is the best choice to present the guide. Videos and a more modern method would have been more appropriate for the Thesis and guide topic. Unfortunately, it was not possible for me to undertake such major changes in the time I had left.

5.3 Competence Development

The thesis process helped me to develop my learning competences. I am now more confident with academic writing and more critical of evaluating sources. I have deepened my knowledge base about strength and balance training for elderly and exergames. I have improved my ethical competences by taking responsibility for my actions and behavior during the thesis process. I understand the conse-

quences of my poor communication with the supervisor teacher and the commissioning party. Furthermore, I am now more capable of instructing and working with elderly clients, and I am more aware of age related changes and its risks.

I was applying my previous acquired knowledge and experience that I gained from the courses and my first practical training, and use it in the thesis. I used my knowledge to work in a customer orientated way. Therefore, it was possible to develop my innovation competences.

The thesis helped me to boost my physical activity competences. I gained more knowledge about the benefits of physical activity and how physical activity develops motor skills, cognitive function and how physical activity can be used to encourage social interactions and be part of a community. My competences in promoting health, physical activity and coaching have improved. I demonstrated exercises with the help of pictures and text and designed a strength and balance guide for elderly.

I was able to learn about my working community competences, and that I need to improve in this area. The thesis helped me to identify my weak points and made me realize how important good communication and time management skills are. I am happy to report that I learned a lot about myself and that the thesis process improved my professional skills, based on the above-mentioned competence development.

LIST OF REFERENCES

Addo, Mary & Eboh, Winifred. (2014). *Qualitative and Quantitative Research Methods. 136-154.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/260181153_Qualitative_and_Quantitative_Research_Methods

American Heart Association. (2008). *Heart Disease and Stroke Statistics – 2008 Update.* Retrieved August 4, 2017, from http://circ.ahajournals.org/content/117/4/e25.short

American Heart Association. (2015). *What Is Peripheral Vascular Disease?* Retrieved August 4, 2017, from http://www.heart.org/idc/groups/heartpublic/@wcm/@hcm/documents/downloadable/ucm_300323.pdf

Anderson-Hanley, C., Arciero, P.J., Brickman, A.M., Nimon, J.P., Okuma, N., Westen, S.C., Merz, M.E., Pence, B.D., Woods, J.A., Kramer, A.F., Zimmerman, E.A. (2012). *Exergaming and Older Adult Cognition A Cluster Randomized Clinical Trial*. American journal of preventive medicine. Retrieved August 4, 2017, from https://www.researchgate.net/publication/221762775_Exergaming_and_Older_Adult_Cognition_A_Cluster_Randomized_Clinical_Trial

Arem, H., Moore, S.C., Patel, A., Hartge, P., Berrington de Gonzalez, A., Visvanathan, K., Campbell, P.T., Freedman, M., Weiderpass, E., Adami, H.O., Linet, M.S., Lee, I.M., Matthews, C.E. (2015). *Leisure Time Physical Activity and Mortality: A Detailed Pooled Analysis of the Dose-Response Relationship.* JAMA internal medicine. Retrieved August 17, 2017, from https://www.researchgate.net/publication/274570764_Leisure_Time_Physical_Activity_and_Mortality_A_Detailed_Pooled_Analysis_of_the_Dose-Response_Relationship

Australian Government, Department of Health. (2006). *Physical Health.* Retrieved March 27, 2018, from http://health.gov.au/internet/publications/publishing.nsf/Content/mental-pubs-p-mono-toc~mental-pubs-p-mono-bas~mental-pubs-p-mono-bas-alt~mental-pubs-p-mono-bas-alt-phy

Betker, A.L., Szturm, T., Moussavi, Z. (2005). *Development of an Interactive Motivating Tool for Rehabilitation Movements.* Retrieved August 10, 2017, from https://www.researchgate.net/publication/6521443_Development_of_an_Interactive_Motivating_Tool_for_Rehabilitation_Movements

Bird, ML., Clark, B., Millar, J., Whetton, S., Smith S. (2015). *Exposure to "Exergames" Increases Older Adults' Perception of the Usefulness of Technology for Improving Health and Physical Activity: A Pilot Study.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/284881544_Exposure_to_Exergames_Increases_Older_Adults'_Perception_of_the_Usefulness_of_Technology_for_Improving_Health_and_Physical_Activity_A_Pilot_Study

Blair, S.N., Kampert, J.B., W. III Kohl, H., Barlow, C.E., Macera, C., S. Jr Paffenbarger, R., Gibbons, L.W. (1996). *Influences of Cardiorespiratory Fitness and Other Precursors on Cardiovascular Disease and All-Cause Mortality in Men and Women.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/14532847_Influences_of_Cardiorespiratory_Fitness_and_Other_Precursors_on_Cardiovascular_Disease_and_ All-Cause_Mortality_in_Men_and_Women

Bogost, I. (2005). *The Rhetoric of Exergaming.* Retrieved August 3, 2017, from http://bogost.com/downloads/I.%20Boogst%20The%20Rhetoric%20of%20Exergaming.pdf

Borghese, A., Pirovano, M., Mainetti, R. & Lanzi, P. L. (2012). *An integrated low-costsystem for at-home rehabilitation.* Retrieved August 19, 2017, from https://www.researchgate.net/publication/261120860_An_integrated_low-cost_system_for_at-home_rehabilitation

Barin, K. & Dodson, E. (2011). *Dizziness in the elderly*. Otolaryngologic Clinics of North America. Volume 44, Issue 2, Pages 437-454.

Brill, P.A., Macera, C.A., Davis, D.R., Blair, S.N., Gordon, N. (2000*). Muscular strength and physical function.* Retrieved February 6, 2018, from http://general.utpb.edu/fac/eldridge_j/kine6362/ancillaryfiles/muscularstrength.pdf

Brown, C. J. & Flood, K. L. (2013). *Mobility Limitation in the Older Patient A Clinical Review.* Retrieved August 5, 2017, from https://www.researchgate.net/publication/256704822_Mobility_Limitation_in_the_Older_Patient_A_Clinical_Review

Campbell, A.J., Robertson, M.C., Gardner, M.M., Norton, R.N., Buchner, D.M. (1999). *Falls prevention over 2 years: a randomized controlled trial in women 80 years and older.* Retrieved February 4, 2018, from https://www.researchgate.net/publication/12695978_Falls_prevention_over_2_years_a_randomized_controlled_trial_in_women_80_years_and_older

Centers for Disease Control and Prevention. (2015). *Physical Activity and Health.* Retrieved August 19, 2017, from https://www.cdc.gov/physicalactivity/basics/pa-health/index.htm

Chatterji, S., Byles, J., Cutler, D., Seeman, T. & Verdes, E. (2015). *Health, functioning, and disability in older adults--present status and future implications.* Retrieved August 4, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/25468158

Cruz-Jentoft, A.J., Landi, F., Schneider, S.M., Zúñiga, C., Arai, H., Boirie, Y., Chen, L.K., Fielding, R.A., Martin, F.C., Michel, J.P., Sieber, C., Stout, J.R., Studenski, S.A., Vellas, B., Woo, J., Zamboni, M., Cederholm, T. (2014*). Prevalence of and interventions for sarcopenia in ageing adults: a systematic review*. Report of the International Sarcopenia Initiative. Retrieved August 10, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/25241753

Csikszentmihalyi, M. (1990). *Flow: The Psychology of Optimal Experience.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/224927532_Flow_The_Psychology_of_Optimal_Experience

De Schutter, B., & Vandenabeele, V. (2008). *Meaningful Play in Elderly Life.* Annual Meeting of the International Communication Association. Retrieved August 4, 2017, from https://www.researchgate.net/publication/242691512_Meaningful_Play_in_Elderly_Life

Department of Health and Human Services. (2004). *Bone Health and Osteoporosis. A report of the Surgeon General*. Retrieved August 4, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/20945569

Diaz, K.M., & Daichi, S. (2013). *Physical Activity and the Prevention of Hyper-tension.* Retrieved August 5, 2017, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3901083/

Diep, L., Kwagyan, J., Kurantsin-Mills, J., Weir, R. & Jayam-Trouth, A. (2010). *Association of Physical Activity Level and Stroke Outcomes in Men and Women: A Meta-Analysis*. Retrieved August 4, 2017, from https://www.researchgate.net/publication/47369566_Association_of_Physical_Activity_Level_and_Stroke_Outcomes_in_Men_and_Women_A_Meta-Analysis

Ferrucci, L., Guralnik, J. M., Simonsick, E., Salive, M. E., Corti, C. & Langlois, J. (1996). *Progressive versus catastrophic disability: a longitudinal view of the dis -ablement process.* Retrieved August 16, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/8630705

Frank, J. & Patla, E.A. (2003). *Balance and mobility challenges in older adults - Implications for preserving community mobility*. American journal of preventive medicine. Retrieved December 15, 2017, from https://www.researchgate.net/publication/9055168_ Balance_and_mobility_challenges_in_older_adults_-_ Implications_for_preserving_community_mobility

Gamberini, L., Fabregat, M., Spagnolli, A., Prontu, L., Seraglia, B., Alcañiz Raya, M., Zimmerman, A., Rontti, T., Grant, J., Jensen, R., Gonzales, A.L. (2008). *Eldergames: Videogames for empowering, training and monitoring elderly cognitive capabilities.* Retrieved August 10, 2017, from https://www.researchgate.net/publication/295148839_Eldergames_Videogames_for_empowering_training_and_monitoring_elderly_cognitive_capabilities

Garcia, J.A., Felix Navarro, K., Schoene, D., Smith, S.T. & Pisan, Y. (2012). *Exergames for the elderly: towards an embedded Kinect-based clinical test of falls risk.* Studies in Health Technologies and Informatics.

Gehrs, K., Jackson, J., Brown, E., Allikmets, R., Hageman, G. (2010). *Complement, Age-Related Macular Degeneration and a Vision of the Future.* Retrieved April 4, 2018, from https://jamanetwork.com/ journals/jamaophthalmology/fullarticle/425202

Gerling, K., Schild, J., Masuch, M. (2012*). Exergaming for Elderly: Analyzing Player Experience and Performance.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/267382366_ Exergaming_for_Elderly_Analyzing_Player_Experience_and_Performance

Gheno, R., Cepparo, J. M., Rosca, C. E., & Cotten, A. (2012). *Musculoskeletal Disorders in the Elderly*. Retrieved August 17, 2017, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3424705/

Haskell, W.L., Lee, I.M., Pate, R.R., Powell, K.E., Blair, S.N., Franklin, B.A., Macera, C.A., Heath, G.W., Thompson, P.D., Bauman, A. (2007). *Physical Activity and Public Health: Updated Recommendation for Adults From the American College of Sports Medicine and the American Heart Association.* Retrieved August 4, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/17762377

Heim, M. (1998). *Virtual Realism*. New York: Oxford.

Heine, C. & Browning, C. J. (2009). *Communication and psychosocial consequences of sensory loss in older adults: Overview and rehabilitation directions. Disability and Rehabilitation.* Retrieved August 22, 2017, from https://www.researchgate.net/publication/235512392_Communication_and_psychosocial_consequences_of_sensory_loss_in_older_adults_Overview_and_rehabilitation_directions

Huberty, J.L., Ransdell, L.B., Sidman, C., Flohr, J.A., Shultz, B., Grosshans, O., Durrant, L. (2008). *Explaining long-term exercise adherence in women who complete a structured exercise program.* Retrieved February 2, 2018, from https://www.ncbi.nlm.nih.gov/pubmed/18816949

Ijsselsteijn, W., Nap, H.H., Poels, K., De Kort, Y. (2007*). Digital Game Design for Elderly Users.* Retrieved August 4, 2017, from https://dl.acm.org/citation.cfm?id=1328206

International Diabetes Federation. (2017). *IDF DIABETES ATLAS*. Eighth edition. Retrieved August 4, 2017, from https://www.idf.org/e-library/epidemiology-research/diabetes-atlas.html

JAMK University of Applied Sciences. (2012). *Service Design Toolkit.* Retrieved March 11, 2018 from telkku.com

Jenkins, H. (2000). *Art Form for the Digital Age.* Retrieved August 23, 2017, from https://web.stanford.edu/class/sts145/Library/jenkins_artform.pdf

K. Gerling, I. Livingston, L. Nacke, and R. Mandryk. (2012). *Full-body motion-based game interaction for older adults.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/241622894_Full-Body_Motion-Based_Game_Interaction_for_Older_Adults

Kari, T., & Makkonen, M. (2014). *Explaining the Usage Intentions of Exergames.* In Thirty Fifth International Conference on Information Systems, Auckland 2014. Association for Information Systems (AIS). Retrieved August 22, 2017, from https://jyx.jyu.fi/dspace/bitstream/handle/123456789/45158/explaining%20the%20usage%20intentions%20ofexergames.pdf?sequence=1

Klijs, B., Nusselder, W. J., Looman, C. W. & Mackenbach, J. P. (2011). *Contribution of chronic disease to the burden of disability.* Retrieved August 7, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/21966497

Krause, Jennifer & A. Benavidez, Eddie. (2014). *Potential Influences of Exergaming on Self-efficacy for Physical Activity and Sport*. Journal of Physical Education, Recreation & Dance. Retrieved August 4, 2017, from https://www.researchgate.net/publication/271822241_Potential_Influences_of_Exergaming_on_Self-efficacy_for_Physical_Activity_and_Sport

Kosse, N., Caljouw, S., Vuijk, P.J. & Lamoth, C. (2011*). Exergaming: Interactive balance training in healthy community-dwelling older adults.* Journal of Cyber Therapy and Rehabilitation. 4. 399-407. Retrieved February 4, 2018, from https://www.researchgate.net/publication/51994865_Exergaming_Interactive_balance_training_in_healthy_community-dwelling_older_adults

Kowal, P., Dowd, JE*. Definition of an older person. Proposed working definition of an older person in Africa for the MDS Project*. Geneva: World Health Organization; 2001. Retrieved March 27, 2018, from https://www.researchgate.net/publication/264534627_Definition_of_an_older_person_Proposed_working_definition_of_an_older_person_in_Africa_for_the_MDS_Project

Kushi, L., Doyle, C., McCullough, M., Rock, C., Demark-Wahnefried, W., Bandera, E., Gapstur, S., V Patel, A., Andrews, K., Gansler, T. (2012*). American Cancer Society Guidelines on Nutrition and Physical Activity for Cancer Prevention Reducing the Risk of Cancer With Healthy Food Choices and Physical Activity.* Retrieved February 4, 2018, from https://www.ncbi.nlm.nih.gov/pubmed/22237782

LaMonte, Michael & N Blair, Steven & S Church, Timothy. (2005). *Physical activity and diabetes prevention*. Retrieved 04.08.2017 from https://www.researchgate.net/publication/7656185_Physical_activity_and_diabetes_prevention

Lange, B.S., Requejo, P., Flynn, S.M., Rizzo, A.A., Valero-Cuevas, F.J., Baker, L., Winstein, C. (2010). *The potential of virtual reality and gaming to assist successful aging with disability.* Retrieved February 4, 2018, from https://www.ncbi.nlm.nih.gov/pubmed/20494281

Lieberman, D. A. (2006). *What Can We Learn From Playing Interactive Games?* Playing Video Games Motives, Responses, and Consequences. 379–397. Retrieved August 4, 2017, from https://www.researchgate.net/publication/285448990_What_Can_We_Learn_From_Playing_Interactive_Games

Lieberman, D.A., Chamberlin, B., Medina, E., Franklin, A.B., Sanner, B., & Vafiadis, D. (2011). *The Power of Play: Innovations in Getting Active Summit 2011 A Science Panel Proceedings Report From the American Heart Association*. Retrieved August 11, 2017, from https://www.researchgate.net/publication/51075934_The_Poer_of_Play_Innovations_in_Getting_Active_Summit_2011_A_Science_Panel_Proceedings_Report_From_the_American_Heart_Association

Michael J. LaMonte, S.N. Blair, Timothy S. (2005). *Role of Exercise in Reducing the Risk of Diabetes and Obesity Physical activity and diabetes prevention.* Retrieved August 4, 2017, from https://www.semanticscholar.org/paper/Role-of-Exercise-in-Reducing-the-Risk-of-Diabetes-Lamonte-Blair/31e484bfc4207be516b978278ae60e9a7323c7a4

Mitchell, W. K., Williams, J., Atherton, P., Larvin, M., Lund, J. & Narici, M. (2012). *Sarcopenia, dynapenia, and the impact of advancing age on human skeletal muscle size and strength; a quantitative review*. Retrieved August 5, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/22934016

Monteiro-Junior, R.S., Vaghetti, C., Nascimento, O., Laks, J. & Deslandes, A. (2016). *Exergames: Neuroplastic hypothesis about cognitive improvement and biological effects on physical function of institutionalized older persons*. Retrieved August 4, 2017, from https://www.researchgate.net/publication/297742167_Exergames_Neuroplastic_hypothesis_about_cognitive_improvement_and_biological_effects_on_physical_function_of_institutionalized_older_persons

Moore, G.E., Durstine, J.L., Painter, P.L. (2016). *ACSM's Exercise Management for Persons With Chronic Diseases and Disabilities.* Fourth Edition. American College of Sports Medicine. Human Kinetics. Champaign.

Nap, H.H., De Kort, Y., Ijsselsteijn, W. (2009). *Senior gamers: Preferences, motivations, needs.* Retrieved August 4, 2017, from https://www.researchgate.net/publication/211726554_Senior_gamers_Preferences_motivations_needs

Nelson, M.E., Rejeski, W.J., Blair, S.N., Duncan, P.W., Judge, J.O., King, A.C., Macera, C.A., Castaneda-Sceppa, C. (2007). *Physical Activity and Public Health in Older Adults: Recommendation From the American College of Sports Medicine and the American Heart Association.* Retrieved December 8, 2017, from https://scholarcommons.sc.edu/cgi/viewcontent.cgi?article=1361&context=sph_epidemiology_biostatistics_facpub

Neufeldt, C. (2009). *Wii Play with elderly people*. International Reports on Socio-informatics. Retrieved August 4, 2017, from https://www.researchgate.net/publication/308606095_Wii_play_with_elderly_people

Nieman, D. (2011) *Exercise Testing and Prescription: A Health-Related Approach.* Edition 7. New York, NY: McGraw-Hill Higher Education.

Nurkkala, V.M. (2014). *Development of Exergaming Simulator for Gym Training, Exercise Testing and Rehabilitation.* Journal of Communication and Computer. Retrieved December 8, 2017, from https://www.researchgate.net/publication/273127577_Development_of_Exergaming_Simulator_for_Gym_Training_Exercise_Testing_and_Rehabilitation

Office of Disease Prevention and Health Promotion. (2008). *Chapter 2: Physical Activity Has Many Health Benefits.* Retrieved August 25, 2017, from https://health.gov/paguidelines/guidelines/chapter2.aspx

Paterson D.H., Warburton D. (2010). *Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines.* The international journal of behavioral nutrition and physical activity. Retrieved August 5, 2017, from https://www.researchgate.net/publication/44589540_Physical_activity_and_functional_limitations_in_older_adults_A_systematic_review_related_to_Canada's_Physical_Activity_Guidelines

Peng, W., Waddell, J.C., Lin, Jih-Hsuan Tammy. (2012). *Using Active Video Games for Physical Activity Promotion.* Retrieved August 5, 2017, from https://www.researchgate.net/publication/228446804_Using _Active_Video_Games_for_Physical_Activity_Promotion

Planinc, R., Nake, I. & Kampel, M. (2013). *Exergame Design Guidelines for Enhancing Elderly's Physical and Social Activities.* Retrieved August 3, 2017, from https://www.researchgate.net/publication/309408968_Exergame_Design_Guidelines_for_Enhancing_Elderly's_Physical_and_Social_Activities

Roubenoff, R. (2000). *Sarcopenia: A major modifiable cause of frailty in the elderly.* Retrieved April 2, 2018, from https://www.researchgate.net/publication/12383585_Sarcopenia_A_major_modifiable_cause_of_frailty_in_the_elderly

Sato, K., Kuroki, K., Saiki, S. & Nagatomi, R. (2015). *Improving Walking, Muscle Strength, and Balance in the Elderly with an Exergame Using Kinect: A Randomized Controlled Trial.* Retrieved February 6, 2018, from https://www.researchgate.net/publication/275221290_Improving_

Walking_Muscle_Strength_and_Balance_in_the_Elderly_with_an_Exergame_Using_Kinect_A_Randomized_Controlled_Trial

Sherrington, C., Whitney, J.C., Lord, S.R, Herbert, R.D., Cumming, R.G. & Close, J. (2008). *Effective Exercise for the Prevention of Falls: A Systematic Review and Meta-Analysis.* Retrieved December 8, 2017, from http://www.laterlifetraining.co.uk/wp-content/uploads/2011/12/Sherrington_Ex_Int_Review_2008_JAGS.pdf

Staiano, A., Calvert, S. (2011). *Exergames for Physical Education Courses: Physical, Social, and Cognitive Benefits*. Retrieved August 5, 2017, from https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1750-8606.2011.00162.x

Stanmore, E., Meekes, W. (2017). *Motivational Determinants of Exergame Participation for Older People in Assisted Living Facilities: A Mixed Methods Study.* Retrieved December 8, 2017, from https://www.ncbi.nlm.nih.gov/pubmed/28684385

Sharma, G. & Goodwin, J. (2006). *Effect of aging on respiratory system physiology and immunology.* Retrieved August 5, 2017, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2695176/

Strait, J. B. & Lakatta, E. G. (2012). *Aging-associated cardiovascular changes and their relationship to heart failure*. Retrieved August 4, 2017, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3223374/

Strawbridge, W.J., Deleger, S., Roberts, R., Kaplan, G. (2002). *Physical activity reduces the risk of subsequent depression for older adults.* American journal of epidemiology. Retrieved August 5, 2017, from https://www.researchgate.net/publication/11206478_Physical_activity_reduces_the_risk_of_subsequent_depression_for_older_adults

Todd, J.A., Robinson, R.J. (2018). *Osteoporosis and exercise.* Retrieved April 2, 2018, from http://pmj.bmj.com/content/postgradmedj/79/932/320.full.pdf

Trout, J. & Christie, B. (2007). *Interactive Video Games in Physical Education.* Journal of Physical Education, Recreation & Dance. Retrieved August 5, 2017, from https://files.eric.ed.gov/fulltext/EJ795570.pdf

Veldhuijzen van Zanten, J., Rouse, P., Halle, E., Ntoumanis, N., Metsios, G., Duda, J., Kitas, G. (2015). *Perceived Barriers, Facilitators and Benefits for Regular Physical Activity and Exercise in Patients with Rheumatoid Arthritis: A Review of the Literature.* Retrieved April 2,2018, from https://doi.org/10.1007/s40279-015-0363-2

Walker, M.L., Ringleb, S.I., Maihafer, G.C., Walker, R., Crouch, J.R., Van Lunen, B. & Morrison S. (2010). *Virtual reality-enhanced partial body weight-supported treadmill training poststroke: feasibility and effectiveness in 6 subjects.* Retrieved February 4, 2018, from https://www.ncbi.nlm.nih.gov/pubmed/20103405

Winter, D. (1995). *Human balance and posture control during standing and walking.* Gait & posture 3 (4), 193-214. Retrieved February 4, 2018, from https://pdfs.semanticscholar.org/7760/b2869f83ff04e595a39a0070283d2ea31c29.pdf

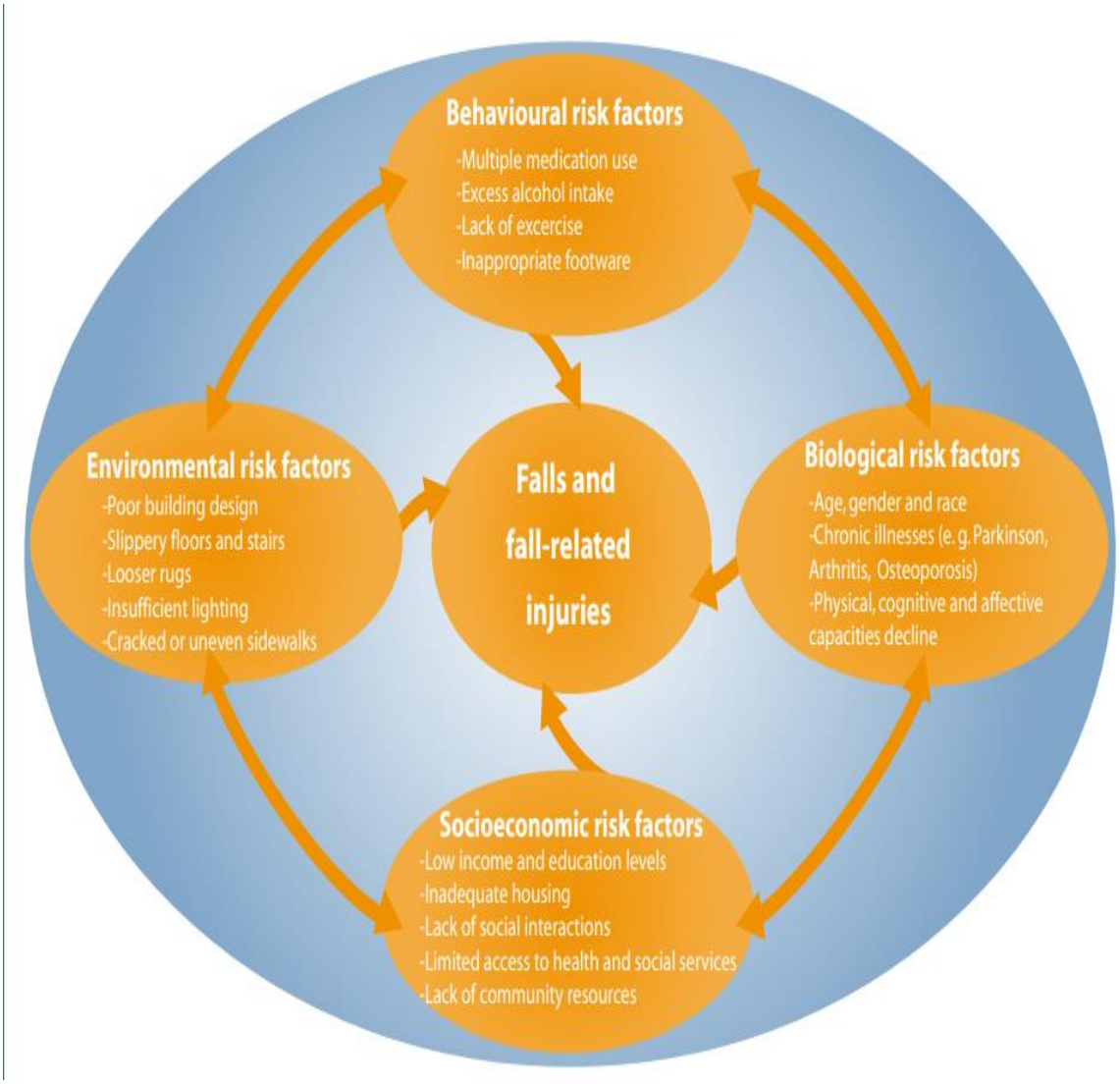
World Health Organization. (2012). *10 facts on ageing and health.* Retrieved August 4, 2017, from http://www.who.int/features/factfiles/ageing/en/

World Health Organization. (2015). World Report on Ageing and Health. Retrieved August 7, 2017, from http://www.who.int/ageing/events/world-report-2015-launch/en/

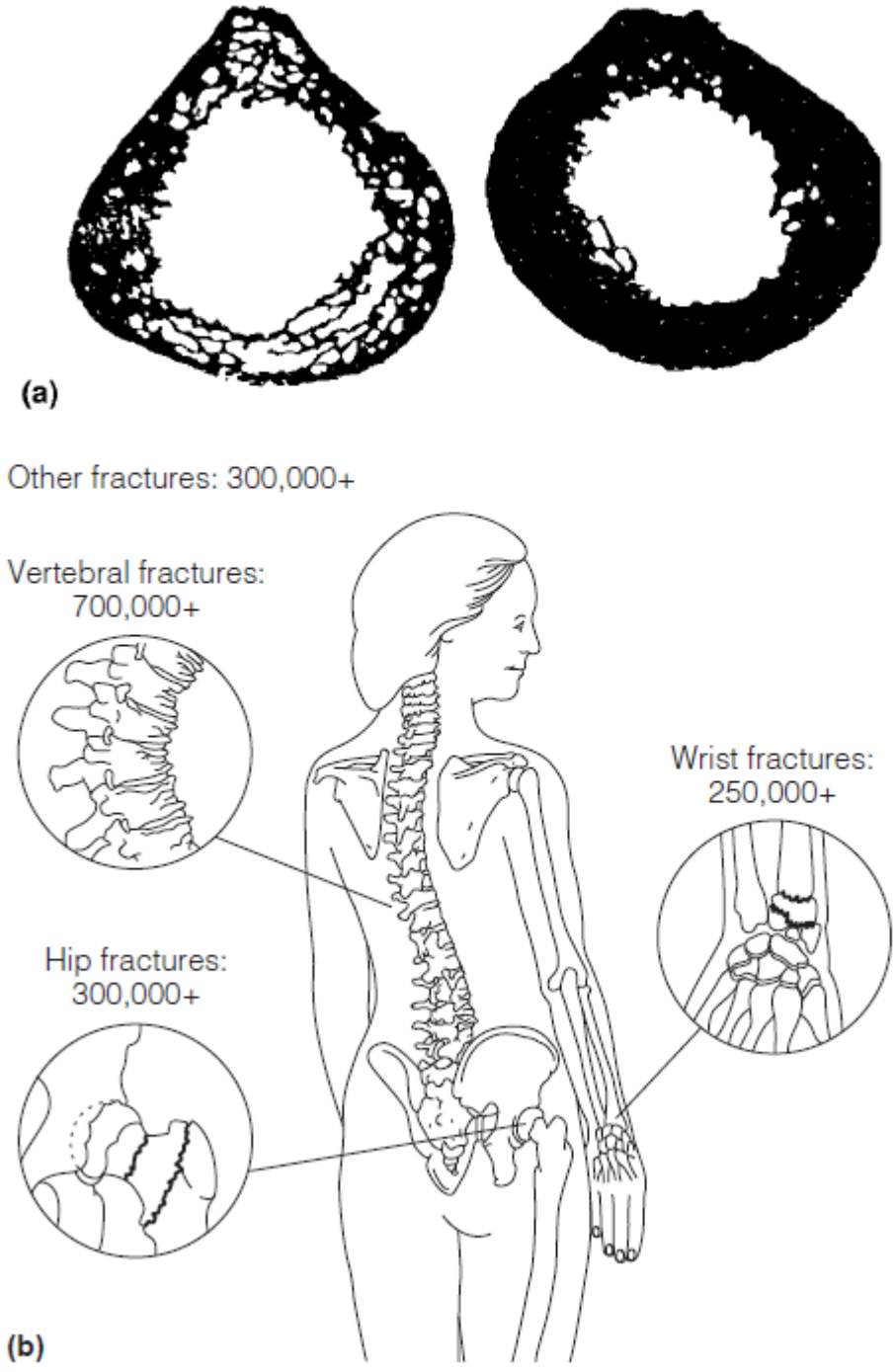
World Health Organization. (2017). *Cardiovascular diseases (CVDs.* Retrieved February 9, 2018, from http://www.who.int/mediacentre/factsheets/fs317/en/

World Health Organization. (2007). *WHO Global Report on Falls Prevention in Older Age.* Retrieved February 9, 2018, from http://www.webcitation.org/6r2v8tsR3

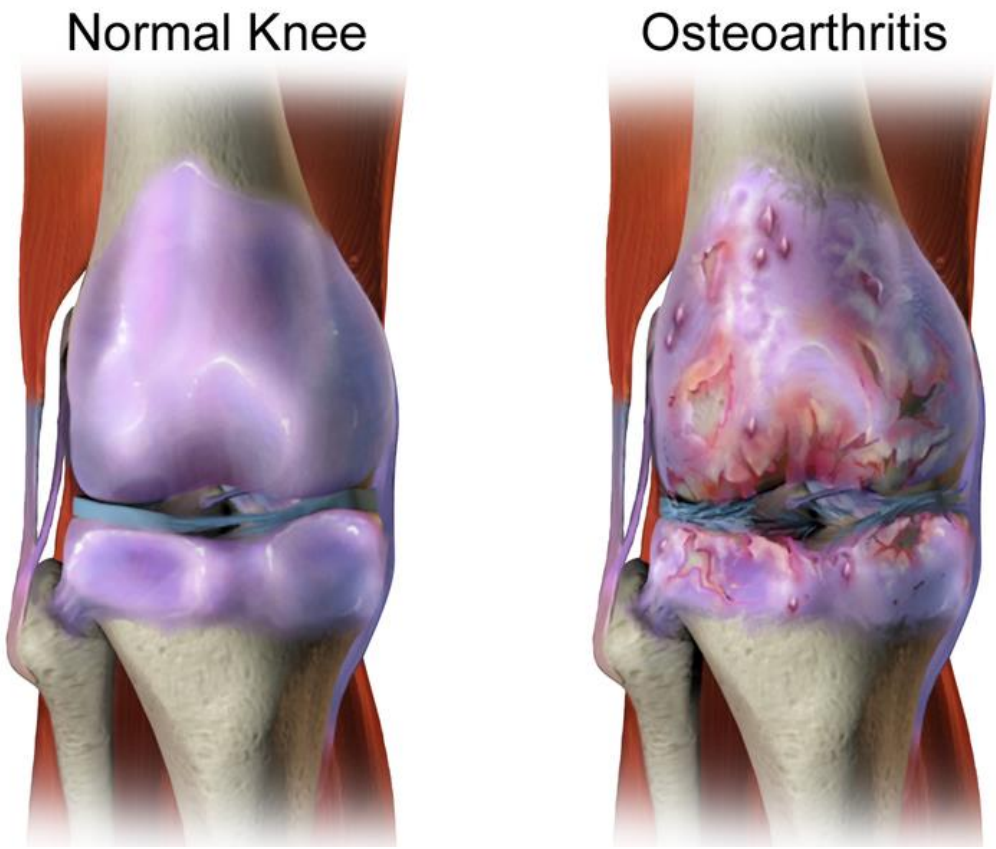
APPENDICES



Appendix 1: WHO (2007). *WHO Global Report on Falls Prevention in Older Age.* Retrieved February 9, 2018, from http://www.webcitation.org/6r2v8tsR3



Appendix 2: Nieman (2011). *Exercise Testing and Prescription: A Health-Related Approach.*



Appendix 3: Taylor (2017). *Effect of Osteoarthritis on Knee Cartilage.* Retrieved February 9, 2018, from https://www.fiercebiotech.com/biotech/after-2-share-crushing-flops-ampio-claims-phase-3-succes