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Physical Activity Intervention for Balance and Fall Prevention in Elderly.

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Abstract

The Finnish population is rapidly aging. It is estimated that by 2050 the number of Finnish citizens over 65 years old will represent about 30% of the whole population.
Aging is related to a progressive decrease in overall physiological component including muscle strength. Moreover, this loss of lower extremities strength is considered to lead to a higher risk of falls among elderly.

The rate of falls, fall-related injuries, and fall-associated costs continue to increase along with the rise of the aging population. Community-based fall prevention interventions for the elderly are surging, in an attempt to address this health burden.
Prevention strategies vary widely in their aim, ranging from single intervention program to comprehensive multifactorial strategies among groups of community-dwelling elderly adults.

The purpose of this Bachelor thesis was to develop an evidence-based training program for elderly with focus on balance. The main research question of this thesis was "How a Multicomponent Physical Exercise Program (MPEP) can affect fall-related physical performance including balance, muscle strength and gait in older people?"

The aim of this study was also to raise awareness about the existence of fall among elderly in the community of Satakunta, and the potential positive impact that physical activity can have in order to prevent these events.
In addition, the whole project can function as a beneficial tool for the authors of this thesis in their future working life as physiotherapist.

Seven community living residents of the Satakunta region in Finland (mean age = 68 years old) with specific fall risk factors (i.e., fear of falling, history of falls or impaired gait or balance) were assigned to a 10 weeks group exercise program (n=20).
The 60-minutes exercise sessions were held twice a week, Monday and Friday from 8th of June to 17th August 2020 focused on increasing strength and balance.

The outcome measurements included three physical performance tests, namely: the Timed up and Go Test, the 30 Seconds Chair Stand Test and the 4 Stage Balance Test. The aim was to assess Gait Speed, Strength and Balance among the participants.

Exercisers showed postintervention improvement in measurements of gait speed by 16,1%, lower limb strength by 19,6% and static balance by 23%.

The authors realized that a MPEP can affect fall-related physical performance such as strength in lower limb and balance with this sample of people. The data collected do also reinforce the notion that a MPEP is a safe and effective way to increase physiological components such muscle strength in this population.

This study provided an effective, evidence-based falls prevention program that can be implemented in community settings to improve physical fitness and might reduce fall risks among this sample group.

Key words:

fall, fall prevention, elder, balance, community dwelling, exercise program, resistance training in frail, endurance training in frail, exercise training in elderly, multi-component exercise interventions, muscle power in elderly, muscle

CONTENTS

1 INTRODUCTION 6
2 AIM AND OBJECTIVE 10
3 FALLS IN OLDER PEOPLE: DEFINITIONS AND BACKGROUND 11
3.1 Epidemiology of falls 13
3.2 Incidence on Healthcare Cost 13
3.3 Risk Factors 16
3.4 The roles and responsibilities of Physiotherapy 17
3.5 Healthy Aging 18
4 CHANGES WITH AGING 20
4.1 Balance 21
4.1.1 Visual System 23
4.1.2 Vestibular System 23
4.1.3 Somatosensory System 24
4.2 Muscle Strength 24
4.3 Motor Control and Gait 26
5 ASSESSMENT TOOLS FOR EVALUATING THE RISK OF FALL 28
5.1 STopping Elderly Accidents, Deaths, and Injuries - STEADI 29
5.1.1 4-Stage Balance Test 30
5.1.2 Timed Up and Go 31
5.1.3 30-Second Chair Stand Test 33
6 FALL PREVENTION INTERVENTION 34
6.1 Relationship between Physical Activity and Falls 35
7 TARGET GROUP 42
7.1 Inclusion criteria 42
7.2 Exclusion Criteria 43
7.3 Subjects 43
8 THESIS PROCESS AND METHODS 45
8.1 Study design 46
8.2 Exercise program for Implementation 47
8.3 Attendance 50
8.4 4-Stage Balance Test 51
8.5 Timed Up and Go Test 54
8.6 30-Second Chair Stand Test 55
9 CONCLUSION 57
10 DISCUSSION 58
REFERENCES 63
APPENDICES

FOREWORD

“The power of community to create health is far greater than any physician, clinic or hospital.”

Mark Hyman

Used Terms and Abbreviations

ACSM	American College of Sport and Medicine
ADL	Activities of Daily Living
AHA	Active and Healthy Ageing
BOS	Base of Support
COG	Centre of Gravity
COM	Centre of Mass
EIP	European Innovation Partnership
IADL	Instrumental Activities of Daily Living
MPEP	Multicomponent Physical Exercise Program
OLST	One-Legged Stance Test
STEADI	Stopping Elderly Accident, Deaths & Injuries
TUG	Timed Up and Go
4SBT	4-Stage Balance Test
30sCS	30-Second Chair Stand

1 INTRODUCTION

The average age allocation of the world population is continuously changing. The increasing number of elderly people and a contemporaneous decrease in the figure of younger persons is a tendency factor around the globe. In Finland it is estimated that by 2050, the number of citizens over 65 years old will represent about 30% of the total population with a total amount over 1,5 million (Website of Stat.fi 2021).
Figure 1 illustrate the age structure of population in Finland on 31 December 2019, and the relative comparison on 1917 (Website of Stat.fi 2021).

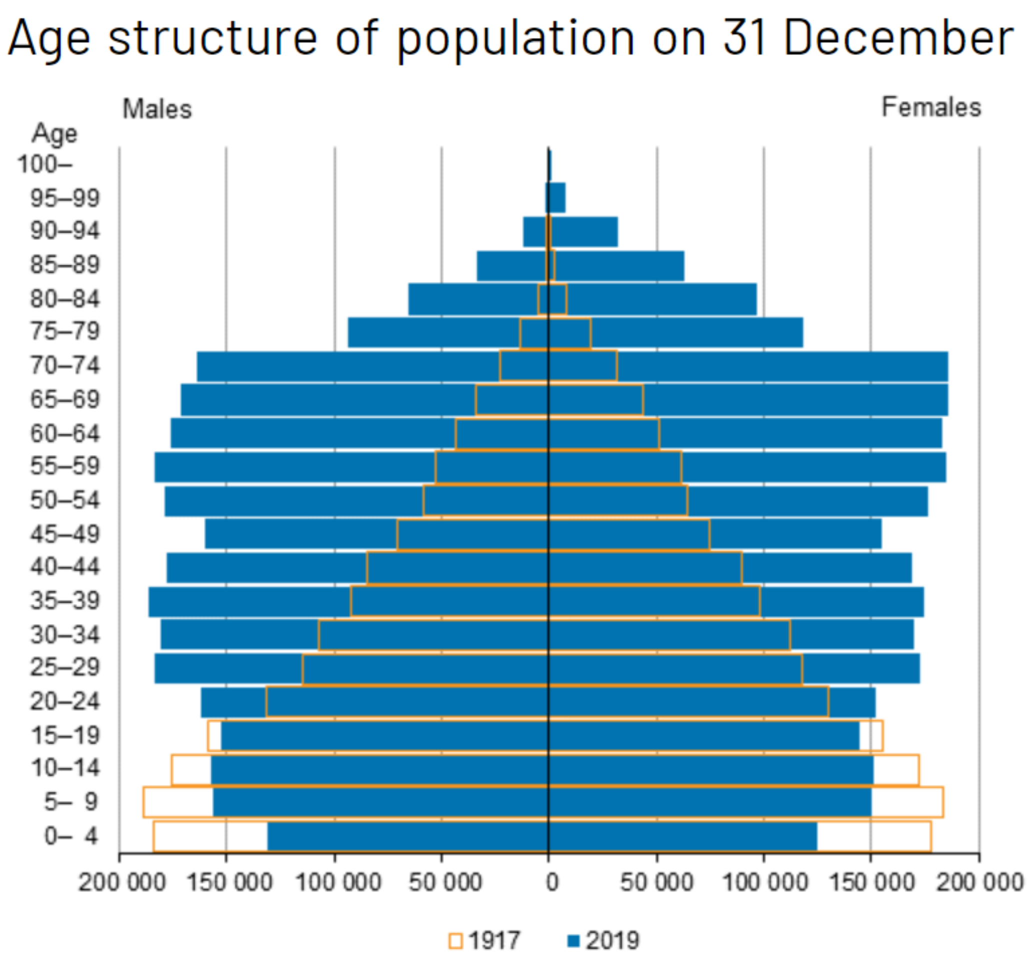


Fig.1 Structure of population Finland 2019 (Website of Stat.fi 2021)

Although the process of aging is a triumph for the humanity, as stated by World Health Organization (2007), it is also a challenge to society. In fact, not only advantages are related to higher life expectancy.

More specifically, a degradation in both physical and cognitive domains of the individuals, which also include the probability in the occurrence of age-related injuries. Furthermore, decrease in muscle strength rather than coordination in the lower extremities lead to a higher risk of falling among elderly (Thomas et al. 2019).

Falls, due to unstable equilibrium, are one of the most frequent geriatric syndromes affecting the everyday life of older persons. In other words, falls are one of the main causes of morbidity and disability within seniors as stated by Guirguis-Blake et al. (2018). Additionally, potential leading causes for use of health care services include for example premature nursing home admissions. The results of these accidents can have significant consequences both physical and psychological. In fact, as stated by World Health Organization (2007), common outcomes of such injuries are hospitalization, disruption of mobility, fear of falling again, activity restriction, functional decline, institutionalization, and even death.

The older people are the more likely they are to fall, and to fall more frequently. Therefore, this has a considerable influence on healthcare cost and health in general. For this reason, it is a major public health problem. According to Phelan et al. (2015), the direct medical costs for falls is in total nearly $30 billion annually in the United States.

As in all other western countries, fall accidents are also a big problem in Finland. Every third over 65 years of age and every other over the age of 80 fall at least once a year. According to Pajala (2012) fall accidents leading to death is also common in Finland. For older men 65% of the accidents lead to death compared to 77% for women. Each year a total of 1300 elderly over the age of 65 die because of a fall or injuries related to the fall in Finland. Minor injuries from falls are treated at home but the older the person who fall is the more likely it is that the injury is going to be more severe. Severe injuries require visits to the hospital which loads the health sector and the society financially (Pajala 2012).

Furthermore, out of all the geriatric conditions, falls is what is threating older people's everyday life and independence the most (Rao 2005). Amongst people over 65 years old, falls are the foremost reason of disabilities and injury deaths (Stevens & Olson

2000). Moreover, as stated by Rao (2005), one of the most complex and expensive health topics in the world are accidental falls and this threat is going to face all older people sooner or later.

As consequence of the fact that injuries related to falls are more often seen in older people, these occurrences not only increase the risk of a premature death. They also increase the risk of loss of independence and are a main reason of pain according to Bergland & Wyller (2004).

According to the data available, every year in the U.S., approximately 19,000 people die from unintentional falls, 500 000 are hospitalized, and 8 million are treated in Emergency Departments (Mertz et al. 2010). Injuries from falls are especially common among the elderly; falls are the leading cause of fatal and nonfatal injuries among people aged ≥ 65 years (World Health Organization 2007). Among these fallers, 20-30% sustained a moderate to severe outcome, these injuries elevate the risk of a premature death and at the same time decrease their independence. Compared to younger adults, elderly is hospitalized five times more often due to injuries related to falls in relation to accident caused by other reasons. Women are also almost three times more likely to be hospitalized due to an injury related to fall compared to men. Different kinds of fractures are also common results related to falls. Fractures in the hip, fore- and upper arm, spine, ankle, hand, and bones of the pelvis are common. Of all these fractures, the hip fracture is the most serious one. In fact, among older adults a hip fracture is a main reason for increased mortality and morbidity (Mundi 2014).

Hospital admissions for a hip fracture increased a lot during 1988-1996 among U.S. population. It was estimated that they increased from 230 000 to 340 000. 80% of all the hip fracture admissions occurred amongst women in 1996 (Stevens & Olson 2000). Additionally, for women aged over 65 years hospitalization due to hip fractures increased with 23% from 1988 to 1996 (Stevens & Olson 2000).

When older people fall it has not only a big impact on their lives, but also for the people close to the person such as friends and family. On top of that it obviously has a big financial impact for the health care utilization in general (Phelan et al 2015).

More research is being done about the topic all the time. The reason for falling is very complex and not only depending on factors related to the environment or the behavior. As a response to this global burden the amount of evidence regarding how to deal with fall related injuries and the prevention of them among older people is rapidly growing. The countries that lead the way and have taken the initiative are apart from the European states also Australia, Canada and USA (World Health Organization 2007).

Significant evidence of the positive outcome of exercise on reduction of the number of falls per person, and the proportion of individual facing one or multiple falls among elderly are available among the literature. In fact, as stated by Sherrington et al. (2017), exercise as a unique implementation has a fall prevention effect like multifaceted interventions.

Moreover, high evidence, including a Cochrane review stated that exercise programs, which include functional exercise and balance drills, decrease the incidence of falls among individual elderly living in the community. However, evidence relation to non falls outcome such as risk of fracture, hospitalization and adverse event remain unclear (Sherrington 2019).

Over the years there has been many different exercise programs regarding fall prevention for elderly both printed and critically assessed. These programs, or studies, differ broadly in their way of searching for the best way to exercise for fall prevention (World Health Organization 2007).

Health and risk assessments have among other things been used to evaluate a person's risk of fall. Different healthcare practitioners have operated together to try to enhance health for elderly people. Amongst other things, potential risks in the home environment have been modified, medication management have assessed polypharmacy, assessment for vision have been performed with possible correction and training programs have been executed both independently and in a group session. Prevention programs have either used all or a combination of some of the mentioned ways to try to prevent and reduce falls in a multifactorial style (Sherrington et al. 2019).

When it comes to older individuals, exercise programs can both decrease the fall risk and decrease the number of falls if the exercise program is executed over time. The most effective exercise programs have been shown to include at least two of the three training components balance training, aerobic endurance training and strength training (Fragala et al. 2019). The training can be completed either individually or in a group. The training equipment needed for a training program can differ a lot depending on what is available at the group session or what is available at home. Rubber bands, dumbbells, bars, cuff weights and machines are examples of equipment that can be used (Chodzko-Zajko et al. 2009).

It is very important that a strength training program targets several muscles in the lower limbs. Exercising tai chi have been shown to both improve both strength and balance at the same time. Practicing weight shift, tandem walking, toe to heal walking, one legged standing and different sit-to-stand activities are also effective actions that improve balance (Fragala et al. 2019). The aerobic/endurance training can be very simple when it comes to improving balance. Just walking, either outside or inside on a treadmill, for 30 minutes three times a week will have a positive effect on balance. However, for a complete fall prevention exercise program to be effective the minimum length of it seems to be 12 weeks (Costello & Edelstein 2008).

2 AIM AND OBJECTIVE

The aim of the thesis is to evaluate the effect an exercise program has on a group of elderly over the age of 60 years old. More precisely the effect it has on their overall physical performance with focus on their balance.

The objectives are to look at the relationship between a Multicomponent Physical Exercise Program (MPEP) held twice a week for ten weeks and the changes on physiological components and functional tasks. A group of elderly people living in the region of Satakunta, Finland, has taken part in a ten-week exercise program between 8th June and 17th August 2020. Specifically, the potential difference between dynamic and static balance is measured together with lower limb strength before and after the training period.

To accomplish the aim of the thesis two main goals were set by the authors.
The first goal was to develop and implement a MPEP held twice a week for ten weeks in a local gym in Mikkola, (Satakunta) namely Fittori Oy. This with the help and supervision of an experienced physiotherapist. The participants were recruited for eligibility screening by advertisements posted in the local Gym Fittori Oy. All potential candidates gathered a thorough explanation of the suggested study, its potential benefits, length of the committed expected time and possible risks.

The second goal of this thesis was to evaluate the effects; before and after the training period, of physical components such as static and dynamic balance, beside lower limb strength of the participants. These components were evaluated by performing the following three tests: The Timed Up & Go Test, the 30-Second Chair Stand Test and the 4-Stage Balance Test.

In summary, the aim of this thesis was to evaluate if there is evidence that a MPEP has effect on physiological components and functional tasks which affects falls in community-dwelling older adults (with pre-frailty).

3 FALLS IN OLDER PEOPLE: DEFINITIONS AND BACKGROUND

As stated by World Health Organization (2007), falls are commonly defined as "inadvertently coming to rest on the ground, floor or other lower level, excluding intentional change in position to rest in furniture, wall or other objects".

The problem with falls in the elderly population is clearly more than simply a high incidence. This because young children and athletes certainly have higher frequency of falls than the frailest elderly groups. However, the different physical condition makes even a modest fall potentially dangerous for elderly (Mertz et al. 2010).

Most studies on the prevalence of falls among elderly has shown that muscle weakness, balance and gait disturbances, functional and cognitive impairment, postural hypotension, central nervous system medications, visual impairment, and foot problems are significant factors associated with increased risk for falls as stated by World Health Organization 2007. In addition to this, as stated by Rubenstein (2006) due an important prevalence of clinical morbidities such as osteoporosis and other age-related changes, recovery has also shown to be delayed.

Figure 2 illustrates the Vicious circle of falling in the elderly (Voermans 2007).

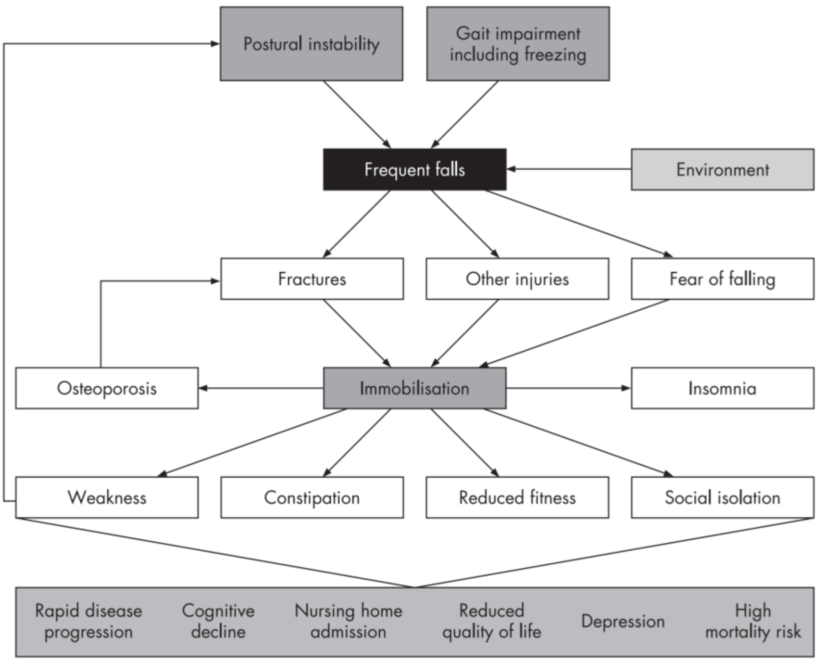


Fig.2 Vicious circle of falling in the elderly (Voermans 2007).

3.1 Epidemiology of falls

According to the available data, injuries caused by falls represents a remarkable part. They are coded as E880-E888 as stated by the International Classification of Disease-9 (ICD-9), and as W00-W19 in ICD-10, which embrace a large array of these injuries (Website of Icdlist 2021). As stated by Phelan et al. (2015), a similar definition such as coming to rest unintentionally on the ground or lower level, not due to an acute overwhelming event could be also used. Notwithstanding, condition such as stroke, loss of consciousness or other circumstances to which any individual would be vulnerable, and might lead to fall, should not be considered as direct cause.

Injuries due to falls are a significant health concerns around the globe, as stated by Yeun (2017). Additionally, according to a previous study, approximately 30% of the elderly aged 65 to 74 years old experienced a fall at least once a year (Phelan 2015).

This percentage, as confirmed by Hewitt et al. (2018) is even higher among residents of long-term aged care, where falls are approximately 3 times more than same age community dwellers. Furthermore, as claimed by Mertz et al. (2010), almost one third of these falls lead to an injury resulting in a physician visit or restriction of regular activity of at least one day.

The way in which a person falls often determines the type of injury sustained. For example, wrist fractures usually result from forward or backward falls onto an outstretched hand and is more common between 65- and 75-years old individuals. Additionally, Rubenstein (2006) states that after age of 75 hip fractures are more frequent due loss or reflex and overall reduction of muscle tissues. These represent a third of all injuries.

3.2 Incidence on Healthcare Cost

For the public health, falls are a significant issue worldwide. This does not mainly affect elderly over 65 years old, but also younger clusters of populations such as children (Mertz et al. 2010). Due to the growing number of elderlies, falls and the relative healthcare consumption are expected to grow in the upcoming years.

The magnitude of this issue is global which also include developed countries, where the size of the impact of falls can be mirrored in the 300% as stated by World Health Organization (2007). This trend might lead to an overload and collapse of the national's healthcare system due to their limited resources (Costello et al. 2008). According to the European Injury Database (Eurosafe 2016) a sample of over 200 hospitals within Europe has shown that yearly about 3.8 million older people attended emergency departments (ED) with fall related injuries. Furthermore, 1.4 million are admitted to hospital for further treatment (Website of Europe.eu 2020). More precisely, among these accidents 50% of all fall-related injuries result in attendance to emergency department because of a fracture. In addition, 1 out of 4 presenting with bruises/contusions, 1 in 10 with open wounds/abrasions, 1 in 20 with sprains/strains, and 1 in 20 presenting with fall-related concussion/brain injury. 1 in 3 cases suffered injuries to the upper extremities, 1 in 3 suffered injuries to the lower extremities, 1 in 5 experienced an injury to the head and 1 in 10 experienced an injury to other parts of the body (Eurosafe 2016).

Due to current inadequacies in many healthcare structures that collect data, the actual number of fall-related attendances and admissions are most likely to be much higher (Eurosafe 2016). Numerous of research have attempted to estimate the overall cost of fall related injuries. Stratified by therapy settings such as emergency department, hospitalization, and outpatient visits, rather than simply sex and age (Burns 2016). As stated by Hartholt et al. (2012), statistics on healthcare and correlated expenses are therefore required to maximize the outcome of local policy, and relative resources allocation in ageing populations.

On the authority of the World Health Organization these causes of injuries represent the second leading involuntary reason for injuries leading to death. An estimation of 646.000 annual victims, preceded only by road traffic accidents (Website of WHO 2020). Furthermore, most of these casualties occur among population with lower income in the region of Western Pacific and South East Asia accounting for 60% of these injuries (Website of WHO 2020).

According to the World Health Organization (2020), about 37.3 million falls require assessment from healthcare providers on annual basis and the relative toll for so called disability adjusted life years (DALY) are over 17 million every year.
Although, the impact of these injuries on rare healthcare resources are increasing dramatically among all the countries, these costs are different in relation to a single nation. In fact, as visible from the data available, the mean of health expenses per fall each year in Finland and Australia are US$ 3611 and US$ 1049 respectively (World Health Organization 2007).

Moreover, incidence-based expenses representation of the Netherlands yearly cost on public healthcare in relation to fall injuries between 2007-2009 has shown a toll of € 674 million globally. This means that each registered fall costed 9370 € on average, for women the cost was slightly higher (9990€). The cost increased in correlation with the age up to 13.000 € (Hartholt et al. 2012).In addition to this, as claimed by Hartholt et al. (2012) hip fractures represent the biggest expense, with a total of 292 million €. This due to the high cost for single case 22.000€ and the relatively large frequency.

Similarities for direct costs of fatal and non-fatal falls among the population came from another analysis done in the United States, based on data from 1998-1999. As stated by Burns et al. (2016) the mean cost of a medically treated fall was estimate to $9780. This with a specify overall cost of a fatal fall of $637.2 million, split by sex, respectively $282.2 million for men and $355.0 million for women. Additionally, non-fatal fall injury treatment cost represented $9.0 billion for men and $22.2 billion for women with a total of $31.3 billion (Burns et al. 2016). For people over 65 years old the toll for fall related injuries reached 19 billion in 2000 according to Mertz et al. (2010). These costs are estimated to increase to $240 billion by 2040 (Costello & Edelstein 2008).

Studies from other states including the United Kingdom, United States, and Australia underline the economic impact of falls related to the healthcare demand. The results of these studies are within the range of previous findings. The highlighted cost of falls among older adults in the United Kingdom was estimated to be 1 billion GBP (12.1 million persons of the age of 60) in 1999. In the United States it was estimated at $19 billion (35 million persons of the age of 65, $372 per older inhabitant) in 2000, and in

Western Australia in Australian of $18 million (200,000 persons of the age of 65, $256 per older inhabitant) (World Health Organization 2007).

In sight of this financial threat, as stated by Sherrington et al. (2017), physical activity interventions aimed to reduce falls among community dwelling elderly, might be the most cost-effective solution to this burden at global level.
In fact, any intervention that potentially delay time to the first accident, by reducing the relative risk of falling, have clinical and economic significance from a public health perspective as stated by Finnegan et al. (2019).

3.3 Risk Factors

According to the World Health Organization (2007) four major risk factors related to falls can be classified, namely: biological, behavioral, environmental, and socioeconomic. Furthermore, the risk of falling increase as the manifestation of these components becomes greater and hence the relative risk of getting injured.

Elderly frequently thinks that environmental and behavioral factors (i.e., rushing, being distracted) are the main reasons for a fall. However, intrinsic factors including personal health are rarely recognized. In fact, as stated by Phelan et al. (2015), when asked what elderly are doing to prevent future falls people commonly report being more careful. However, there is no evidence that being more careful alone prevents falls. Furthermore, only half of the older adults who fall talk about it with their health care providers. They underrate the related potential risk for a fall (Phelan et al. 2015).

Multiple research have broadly described the effectiveness of multicomponent fall prevention interventions, including education, environmental modification, exercises, and psychological programs (Sherrington 2017). As stated by Zhuang et al. (2014) exercise intervention is one of the most important components in a multifactorial fall-prevention program.

Furthermore, these positive effects also show in the injury prevention due to falls. As stated by El-Khoury et al. (2013), the protective effect seems more significant for the most serious fall related injuries. More specifically diminution appear about 37% of all injurious falls, 43% for severe injurious falls, and 61% for falls resulting in fractures.

Also, environmental factors such as obstacles on footpath rather than inappropriate assistive aids or simply slippery surfaces, must be considered. Phelan et al. (2015) states that assessment and change environmental risk factors is an essential intervention as part of a thorough multidimensional approach to foresee and reduce falls. Other identifiable risk factors are muscle weakness, confusion, polypharmacy, or gait issues that are linked with most falls. Studies have shown that attention to these risk factors can reduce drastically the percentage of falling (Rubenstein 2006).

Another complication is the so-called post-fall anxiety syndrome. The syndrome describes an individual down-regulating activity in a perhaps overcautious fear of falling; consequently, this further contribute to deconditioning, weakness and abnormal gait and in the long run may actually increase risk of falls (Rubenstein 2006).

3.4 The roles and responsibilities of Physiotherapy

According to the definition of the “World Confederation of Physical Therapy”, a physiotherapist provides services that develop, maintain, and restore people’s maximum movement and functional ability. They can help people at any stage in life, when movement and function are threatened by ageing, injury, diseases, disorders, conditions or environmental factors (Website of WCPT 2020).

Primary care, physiotherapists included, provide an important role in supporting patients understanding the main factors involved in the risk of fall. Features such as individual and environmental and their relation to falls (Phelan et al. 2015).

A physiotherapist usually evaluates balance, strength and gait deficits before planning customized goals based on the clients own functional abilities. Primary objectives include the contraction of probability of falling, and the relative risk of injury for patients. Additionally, the maintenance of their highest possible level of functioning is crucial. As well as regular follow-up to evaluate their functional ability (Website of NICE National Institute for Health and Care Excellence 2020). According to Shaffer & Harrison (2007) physiotherapists are faced with the difficult task of assessing elderly with sensorimotor impairments and then precisely address these deficits in relation to the individual functional abilities.

Furthermore, an evidence-based exercise program should be advised regularly to all patients over 65 years old. In fact, reduced functional degeneration and relative injuries could be avoided simply with these tailored interventions made by the health care provider. As stated by Gillespie et al. (2012) in a Cochrane Systematic review, identification and relative management of risk factors done by the caregiver can significantly reduce the percentage of falls up to one quarter. Understanding the perspective of the elderly and how to promote their involvement in fall prevention actions is crucial for the accomplishment of the caregiver's effort in this field.

Additionally, the social competences of a physiotherapist are reflected via his/her participation in social activities, monitoring changes in society, and devising responses to these changes. As stated by Hynynen et al. (2017) a physiotherapist must be aware of national and international changes in trends that affect society, for example, demographic developments, the ageing of the population, multiculturalism, and the economic and political situation.

3.5 Healthy Aging

Due to the increasing trend of the proportion of older people an appropriate long-term health condition program among that population is required. Fall prevention, represent a critical global challenge for the public health in any country as stated by Finnegan et al. (2019). As many studies highlight, most of the risk factors related to chronic disease increase with age. Therefore, the adoption of regular physical activity is essential to offset the functional declines which occur with aging (Chodzko-Zajko et al. 2009).

Participation in a regular physical activity program is one of the most cost-effective interventions of all the well-known health benefits for elderly. Despite this, only 22%

of adults over the age of 65 in the United State of America meet the recommendations for physical activity. Furthermore, only 32% of clinicians seems to prescribe exercise counseling or education to their elderly patients, even though the ability they have to adapt and respond to both, aerobic and strength training program, as claimed by Zaleski et al. (2016). According to the World Health Organization (2007) every person – in every country in the world – should have the opportunity to live a long and healthy life. Healthy ageing is about creating the environment and opportunity that enable people to be and do what they value throughout their lives. This process requires the development and maintaining of the functional ability that empowers wellbeing in older age.

Functional ability is made up of the intrinsic capacity of the individual, relevant environmental characteristics, and the interaction between them. Intrinsic capacity refers to all the mental and physical capacities that a person can draw on. Including their ability to walk, think, see, hear and remember. The level of intrinsic capacity is influenced by several factors including age-related changes (Website of WHO 2020).

At European level, several initiatives focus on enhancing healthy aging. In particular, the European Innovation Partnership in Active and Healthy Ageing (EIP and AHA) aim to create partnerships and synergies. This through targeting and strengthening of research and innovation among the European Union (Website of Europa.eu 2020).
Furthermore, the EIP and AHA aim to endorse active and healthy ageing, facilitating the cooperation among all the relevant stakeholders across the European Union. This at local, regional and national level. Being aware of the importance to tackle this specific societal challenge, the EIP and AHA is aiming to increase the average healthy lifespan of EU citizens by two years by the year 2020 (Website of Europa.eu 2020).

4 CHANGES WITH AGING

Although within the literature concerning aging there is no consensus regarding when one can be classified as an elderly. There is neither any particular guidelines about the minimum age of participants in studies that examine the aspects related to aging (Xue 2011). However, according to Chodzko-Zajko et al. (2009) in the American College of Sport and Medicine they suggest that usually ‘‘old age’’ guidelines apply to individuals aged 65 years old or older. Nevertheless, adults aged 50–64 years old with clinically significant chronic conditions or functional limitations that affect activities of daily living, rather than fitness or physical activity can also be included in this category (Chodzko-Zajko et al. 2009).

The percentage of elderly constitutes a significant share of the global population and is constantly increasing (World Health Organization 2007). With aging, vision, peripheral sensation, and vestibular function tend to decrease. Consequently, reduced balance and strength increases the risk of fall and fall-related injuries as pointed out by Rubenstein (2006).

A decline in physical components and relative vital function is perceived by elderly and lead to frailty. This status can, according Chittrakul et al. (2020), be described as a decay of several physiological features. These features might lead to an array of negative outcomes including multiple-diseases or hospitalization. More precisely, according to Xue (2011), frailty is theoretically explained as a clinically noticeable condition of enlarged vulnerability. This result from aging-related diminution across an array of physiologic factors referred to the ability to cope with activities of daily living. Furthermore, in presence of three out of these five conditions or phenotypic criteria, namely, weak grip strength, low energy, slowed waking speed, low physical activity, and/or unintentional weight loss. A subject is potentially classified as frail. Hence, prone to a cycle of negative energy balance, sarcopenia, and diminished strength and tolerance for exertion.

This syndrome, which comprises several domains and include both physical and mental impairments, show a significant prevalence in people older than 65 years of age.

More specifically the range vary among 7% to 16% of the population and seems to increase with age. This is the main risk factor for disability among elderly according Cadore et al. (2013).

4.1 Balance

Balance, which also can be defined as postural equilibrium, is achieved when the center of mass (COM) of the body is controlled in relation to the base of support (BOS). More specifically it is required a continuous muscle activation and joint positioning aiming to keep the COM over the BOS (Trew & Everett 2005).

Additionally, according to the website of Physiopedia (2020), balance refers to an individual's ability to maintain their postural control and center of gravity (COG) within their Base of Support (BOS). This condition of equilibrium stands for any state where all the forces cancel each other out and the consequence is a steady balanced system (Website of Physiopedia 2020).

Balance is a compound multi-factorial apparatus that includes cognitive, motor- and sensory components. All these components interact with the surrounding environment and between each other. This depending on the difficulty of the task that is about to be performed as stated by Gervais et al. (2014).

Balance can be divided into two separate types. Keeping the balance whilst standing is called static balance, whilst dynamic balance refers to keeping equilibrium when moving. Improving both types of balance will not only reduce the risk of falling but also enhance quality of life and in general improve the performance in any physical activity (Website of Myofitclinic 2020).

Likewise, according to Rubenstein (2006), all activities of daily life are balance dependent. Balance is surprisingly easy to improve and/or maintain, and it is at the same time one of the most underrated characteristic when it comes to daily function as well as general well-being.

No one of us can escape from growing old, which will have a steady negative effect on our balance. Hence our risk of falling goes hand in hand with ageing. Consequently, equilibrium and postural stability can be affected and might result in injury and hospitalization due to falling (Chodzko-Zajko 2009).

However, balance is something that can be maintained and improved by taking part in a physical activity program for instance. In fact, adapted physical activity can improve proprioception. On top of that, taking part in regular training or physical activity support the muscle activity and increases mobility of the joints. This will support the distribution of weight evenly and create a better stability overall. These factors will all contribute to decrease the risk for falls (Website of Myofitclinic 2020).

A key factor when it comes to determine success against falls, among different intervention, is the sort of training performed. In sight of the available evidence, balance or stability training on top of an intervention, appears to lead to better outcomes as stated by Cadore (2013). More specifically, the intensity of the balance training part determines the effectiveness of the intervention. In fact, according to one study done by Cadore (2013), it was shown that interventions that included more advanced balance exercises have been more beneficial in terms of preventing falls, compared to interventions that involved less advanced exercises.

These more challenging exercises can be performed in standing position. Examples of these kind of movements patterns include feet close together, standing on one leg, minimizing the use of hands; assisting or to improve to control COM in different movements (El-Khoury et al.2013).

However, as highlighted by Cadore et al. (2013), the effects of balance training on the risk of falls should be carefully analyzed by the provider, since the effectiveness of this intervention has been demonstrated only when it is combined with other components of physical fitness, such as strength and endurance training.

According to Trew & Everett (2005) multiple systems are contributing to achieve this state of equilibrium during standing and moving in different environments. In fact, the central nervous system needs continuous feedback from movement. This information is provided by different sensory systems, namely the vestibular system, the visual system, and the somatosensory system (Website of Physiopedia 2020).

4.1.1 Visual System

The visual system provides crucial information concerning the position of the individual in relation to space as stated by Trew & Everett (2005). This essential part of balance mechanism is provided by eyes movements and correlated input.More specifically it is possible to distinguish two functional classes of eye actions. The first being those that stabilize the eyes when the head moves or appears to move, namely “gaze stabilization” and the second being those that keep the image of a visual target focused on the fovea of the eye, when this changes or moves defined as “gaze shifting” (Website of Physiopedia 2020).With the help of these cues, the central nervous system is first capable of distinguishing from where the sensed movement is created. And then to predispose the relative compensatory maneuver by specific muscle activation as highlighted by Trew & Everett (2005).

4.1.2 Vestibular System

The vestibular system, as pointed out by Purves et al. (2001), provides the sense of equilibrium and the information in relation to the body position that leads to compensatory movements in response to forces. This system consists of three semicircular canals filled with liquid, which responds to movements of the head. The moving liquid stimulates hair cells, which then send the information to the central nervous system (Website of Physiopedia 2020). Moreover, as claimed by Trew & Everett (2005), this peripheral portion, which is a part of the inner ear, is continually reporting information related to body position to the integrative centers located in the brain namely sensory cortices, cerebellum and brainstem. The vestibular system plays a crucial role in the postural balance and correlated functions. In fact, as stated by Purves et al. (2001), if the system is damaged, balance, control of eye movements when the head is moving, and sense of orientation in space are all adversely affected.

4.1.3 Somatosensory System

The somatosensory system notifies us, throughout proprioception, about the position and movement of an individual´s body part in our surrounding environment.
As claimed by Trew & Everett (2005) this system is based on cutaneous stimulus such as touch and pressure, which are perceived through feet for example. Furthermore, according Shaffer & Harrison (2007) proprioceptors of muscles and joints, namely Muscle Spindles and Golgi tendon organs, detect change in length of a muscle and provide information about the position of body segment and alignment. As stated by Trew & Everett (2005) the information processed by this system travel along different anatomical pathways depending on the information carried. These multimodal afferent inputs are integrated at various levels of the central nervous system, resulting in efferent processing for the organized activation of several alpha motoneurons and their relative muscle fibers for compensatory movement.

4.2 Muscle Strength

Aging is associated with a progressive loss of muscle mass and relative strength. The diminishment of muscle power might lead to impairment in performance of ADL and IADL (Liu & Latham 2009). Also, muscle strength reaches its peak in the second and third decades of life as stated by Lee & Park (2013).

Beside this, there is strong evidence that sedentary behavior, absence of regular exercise and malnutrition leads to a reduction in muscle strength. Consequently, on proprioception, balance, and functional capacity, which can cause falls in the elderly and lead to disability and more in general, overall vulnerability to injury (Chittrakul 2020).

Namely Sarcopenia, this unintentional reduction of strength and more specifically muscle mass, progress at an average rate of approximately 3–8% per decade after the age of 30 according to Volpi, Nazemi & Fujita (2004). Nevertheless, in elderly this pace is higher, especially after the age of 60. More specifically, a steady but minimal decline is continuous until approximately 50 years of age. After that a more rapid drop has been shown, a rate between 1.4% to 2.5% per year after the age of 65 (Lee & Park 2013).

This loss of skeletal muscle mass and relative strength is the consequence of anatomical and biochemical changes in the aging muscle as stated by Xue (2011). Several are the mechanisms occurring through sarcopenia such as oxidative stress, dysregulation of inflammatory cytokines and hormones and muscle apoptosis, which might lead in most cases to overall frailty (Volpi, Nazemi & Fujita 2004).

In addition, a constant rise of fat mass is visible with mutual effect on the overall body composition. Moreover, bone density decreases, joint stiffness increases, and there is a small reduction in stature. Nutrition and physical level of activity might be accountable for the evolution of sarcopenia according to Volpi, Nazemi & Fujita (2004).

Although this process affects both genders, distinct characteristic can be seen among women and men. Mangione et al. (2010) states that loss is steadier between men compared to women, where the deficiency after menopause is more highlighted.

Compensatory strategies might be undertaken for management of Sarcopenia. Several studies have consistently demonstrated that, given a stimulus of sufficient intensity, muscle strength increases also in older adults. Moreover, according to the American College of Sport Medicine (ACSM), adults over 65 years old should be encouraged to engage in 30 minute of moderate-intensity aerobic exercise five times a week, combined with resistance training at least twice a week (Chodzko-Zajko 2009).
In addition to this, as stated by Lee & Park (2013) further evidence come from several research, which, utilized traditional progressive strength training approaches. These have focused on the development of muscle strength and increased muscle mass to slow or reverse the effects of sarcopenia in older adults. These types of strength training improved older adults' muscle mass, strength, and overall high-load power.

In addition, the literature available have also shown the correlation between the ability to perform activities of daily living (ADL) and the strength of the lower limbs. Zhuang et al. (2014) states that better balance is associated with a major strength in knee extensors and flexors which facilitate a better gait. Likewise, a generation of more muscle force increase the speed in the final phase of stance with the consequence of move the center of gravity further away from the previous base of support.

Equally important, according to a systematic review done by Cadore et al. (2013), no side effects were highlighted in the studies that investigated the effects of strength training in frail elderly subjects.

4.3 Motor Control and Gait

The manner or style of walking, namely Gait; as stated by Physiopedia (2021), depends on several interaction of major parts of the nervous-, musculoskeletal- and cardiorespiratory systems.

The individual gait pattern is influenced by multiple factors including age, gender and sociocultural characteristics. The preferred walking speed among older adults is a sensible marker of overall health and survival (Pajala 2012). In fact, difficulties in walking lead to a loss of personal freedom, falls and injuries. Hence it results in a significant reduction in the quality of life. In addition to this, as stated by Cadore et al. (2013), walking requires intact cognition as well as executive control to be considered safe.

The normal forward step consists of two distinct phases namely stance and swing. The former occupies 60% of the gait cycle, during which one leg and foot are bearing most of or all, of the body weight. The latter phase occupies only 40% of it, during which the foot is not touching the walking surface and the body weight is borne by the opposite foot (Website of Physiopedia 2021).

The gait of elderly is often stiffer, less coordinated and overall, more unstable than younger peoples. This decrease in functional ability affect “movement strategies”, namely “hip” and “step”. These compensatory strategies are aimed to correct in time body position and avoid falls. Besides that, they have an impact on posture control, body-orienting reflexes, muscle strength and tone, and the height of stepping (Rubenstein 2006).

Reductions in aerobic capacity, VO2max and strength, due to aging suggest, according Chittrakul et al. (2020) that work like for example walking at a submaximal speed require a higher percentage of maximal capacity. This among elderly in comparison with younger individuals.

Falls during walking are the primary cause of accidental injury in older individuals, in fact as Mertz et al. (2010) states, one third to one half of falls among elderly over 65 years occur while walking. Although men have a higher death rate from falls among elderly, women are more prone to report a fall. Women are also more likely to suffer injuries from falls, most likely due to lower density of bone mass (Mertz et al. 2010).

These issues are results of both physiological changes due to sedentary lifestyle and specific dysfunctions of the nervous-, muscular-, skeletal-, circulatory- and respiratory systems. To prevent falls an adequate level of strength and overall level of fitness, especially of the lower limbs play a significant role according to the data available (Phelan et al. 2015).In fact, evidence shows that that 12 weeks of strength and balance training increase isokinetic strength by 21% for the knee flexors and 26% for the knee extensors. As a consequence, walking speed increase which will lead to a reduce in fall rates (Rubenstein 2006).

It is also equally important to take the results of previous research into account.
These outcomes show that a notable increase in ankle and hip range of motion lead to an increase in stride length and step frequency. This because of strength improvement in muscles such as the gluteus maximus, the hamstrings and the quadriceps femoris (Cadore et al. 2013).

Furthermore, the significant reduction of the double support phase confirmed the finding seen in the isokinetic data, caused by increased ankle plantar flexor strength (Zhuang, Huang, Wu & Zhang 2014). Finally, analysis of fitness and physical activity show that they appear to protect against walking-related falls. These habits convey many other health benefits as well. They also protect against the risk of heart disease, stroke, different cancers, and diabetes (Chodzko-Zajko 2009).

5 ASSESSMENT TOOLS FOR EVALUATING THE RISK OF FALL

Falls are events that are possible to avoid or decrease by detecting certain elements, through specific appraisal tools. These together with a necessary evaluation done by healthcare professionals, could lead to take appropriate and preventive actions (Lohman et al. 2017).

According to Rubenstein (2006), the Public Health Service of the United State shows that 2/3 of the fatal injuries related to fall could be foreseen. This based on previous analysis of causes of severe falls. In fact, significant share of falls among elderly arises along daily activities such as transfers and walking (Rapp et al. 2012).

Although the chances of falls are related to the functional ability, as stated by Phelan et al. (2015), individual´s capability of functioning is assessed with the help of standardized assessment tools focused on difficulties with executing both ADL and IADL.

Several appraisals' methods have been designed to evaluate possible risks of fall in clinical settings. The Stopping Elderly Accidents, Deaths, and Injuries (STEADI) tool was created to promote fall risk screening and encourage coordination between clinical and community-based fall prevention resources (Lohman et al. 2017).

The aim of this bachelor thesis was to evaluate the effects; before and after the training period, of physical components such as static and dynamic balance, as well as lower limb strength of the participants. These components were evaluated by performing the following three tests, before and after the intervention: The Timed Up & Go Test, the 30-Second Chair Stand Test and the 4-Stage Balance Test.

The tests used for this appraisal have been taken from “Centers for Disease Control and Prevention National Center for Injury Prevention and Control” and are a part of the “Algorithm for Fall Risk Screening, Assessment, and Intervention” (Website of CDC STEADI 2020).

There are many studies that have confirmed the validity of these tests like for example a review made by Sarmiento & Lee (2017). STEADI, has been designed to help health care providers with the assessment of their patients, and to apply correlate interventions and evidence-based strategies. Mainly among elderly in order decrease their risk of fall. In sight of this reason, the authors of this thesis decided to implement their research with these mentioned tests.

In the end of the training period the tests results were compared to measure the eventual effectiveness the training period have had on the participant's balance, and more in general on their physical performance.

5.1 STopping Elderly Accidents, Deaths, and Injuries - STEADI

According to Lohman et al. (2017), the Centers for Disease Control's Stopping Elderly Accidents, Deaths and Injuries (STEADI) tool was planned with the aim to facilitate fall risk assessment into routine practice. The goal of STEADI is to improve the skills of healthcare providers to screen periodically risks for falls among elderly patients. Furthermore, according Eckstrom et al. (2017) this toolkit assesses whether subjects have modifiable fall risk factors and treat those throughout evidence-based interventions.

The STEADI toolkit includes guidelines for assessment, implementation, treatment, and referral. An evidence-based algorithm screens the fall risk of an individual during clinical visits. The screening algorithm tool is the result from population-based research on fall risk factors. This assessment appraisal has been integrated into clinical practice and community-based fall prevention programs (Website of CDC STEADI 2020).

This algorithm is used to classify participants in fall risk group, throughout a list of hierarchical questions and physical assessments (Website of CDC STEADI 2020).

As stated by Burns et al. (2016), this toolkit incorporates advice on how to screen for fall risk and conduct efficacious clinical fall interventions. This includes optimization of patient's medications to reduce accidents and recommending supplements, with the aim to decrease the incidence of fall injuries and therefore reduce health care costs (Burns et al. 2016).

Additionally, according to Phelan et al. (2015), an evaluation done by this algorithm can be useful even for those who do not at the moment, shown any difficulties with balance and gait, or do not have history of fall. In fact, a primary educational intervention about strengthening of muscles, balance exercises and correct food supplementation can affect future fall and relative risk factors (Phelan et al. 2015).

5.1.1 4-Stage Balance Test

The first test part of the STEADI protocol, namely the 4 – Stage Balance Test (4SBT) is an evaluation tool that assesses mainly static balance. 4SBT, evaluate the ability of an individual to hold four gradually more challenging positions (Website of Physiopedia 2020). This timed multi stance test is a simple test for evaluating static aspects of balance. It can be used in a variety of settings and requires minimal equipment or training.

This evaluation of static balance, in four stage balance tests is carried out by having the patient stand in 4 different bearing stands with open eyes (Website of CDC STEADI, 2020). More precisely, these stances are the parallel, semi-tandem, tandem and single-leg stand. According to research available the inability to perform a tandem stand (i.e. heel of one shoe touching toe of the other) for 10 seconds predicts falls, and the inability to stand on 1 leg unassisted for 5 seconds predicts injurious falls (Phelan et al. 2015). A copy of the form utilized for this thesis can be found in Appendix 3.

Likewise, One-Legged Stance (OLST) with the eyes open is highly reliable for testing health-related functions and measures postural stability including balance. The test is more difficult to perform due to the narrow base of support. The OLST is described according to the literature available, as a method useful in explaining other variables of importance. Variables such as frailty and self-sufficiency in activities of daily living as well as fall status (Springer et al. 2007).

According to a review of normative value for the unipedal stance test, results confirm the hypothesis that there is a significant age dependent decrease in the ability to stand on one limb. This with both the eyes open and both eyes closed (Springer et al. 2007). Abnormal results on stance test time with the eyes open might be related to conditions such as peripheral neuropathy and intermittent claudication as stated by Springer et al. (2007).

Besides this, a correlation among shorter time recorded in a certain stage is associated with an increased risk for falls. Even though it is not included in this thesis project, if conducted the test with eyes closed it could lead to gathering other valuable information. In fact, patients with other clinical conditions which affect the vestibular organs would be at an increased chance of fall due to the eliminated visual input. In addition to this, a study made by Springer et al. (2007) highlighted a significant age dependent decrease in the ability to stand on one foot both with eyes closed and open, however this was not gender specific.

This correlation between age and balance, that diminishes as age increases, was confirmed also by a meta-analysis done by Bohannon (2006) that focused on single leg stance time. In fact, in this stage elderly subjects might have difficulty maintaining their balance due to difficulty adjusting postural control in the initial dynamic phase of one-leg stance. On top of that also a diminution in lower extremity muscular strength and endurance may affect the results (Bohannon 2006).

5.1.2 Timed Up and Go

The Timed Up and Go test (TUG) was developed in 1991, it is an assessment tool widely utilized by therapists to evaluate the risk of falls among individuals (Barry et al. 2014, Thrane et al. 2007). The test has also a good inter-rater reliability for dynamic balance and functional mobility evaluation. This has been shown using the tool according to Zhuang et al. (2014). A copy of the form utilized for this thesis can be found in Appendix 1.

This test might be used to screen mobility, walking ability and balance in older adults (Website of Sralab 2020). According to the literature available a result time greater or equal to twelve seconds might indicate higher risk of fall (Phelan et al. 2015).

The TUG test measures the time it takes for a person to rise from an armchair (seat height 46 cm), walk at a brisk and safe pace until a mark on the floor three meters away, turn and walk back to the same chair and sit down again. Usually, one attempt to get familiar with the test has been given to the ones tested before being timed (Bohannon 2006).

However, according to a meta-analysis review made by Bohannon (2006), instruction gathered did not show uniformity when stipulated with the participants. The guideline is usually to call for moving at a normal, comfortable, or self-selected speed; but they sometimes indicated that the test should be performed 'quickly.' Additionally, some trial included one or more practice and timing commenced with the command 'go' or 'start' or sometimes with movement of the subject (Bohannon 2006).

Although, this tool has been largely advised by the American Geriatric Society, the British Geriatric Society and The National Institute of Clinical Evidence (NICE) as a regular screening test in the prevention of falls in older (Barry et al. 2014, Thrane et al. 2007). The literature is on its predictive diagnostic accurateness for determine future falls is not completely straightforward as highlighted by Kang et al. (2017).

More precisely, some researchers reported that TUG can distinguish between fallers and non-fallers retrospectively, notwithstanding other studies shown that it is not related to falls measured prospectively in older adults (Applebaum et al. 2017).

Additionally, according to a systematic review and meta-analysis made by Barry et al. (2014), the TUG test should not be used to evaluate risk of fall among elderly, at least not if used in isolation.

The reason for this discrepancy is not apparent, but perhaps the TUG is not a sensitive indicator of deterioration in strength and balance (Applebaum et al. 2017).

5.1.3 30-Second Chair Stand Test

The third part of the STEADI test protocol include assessment of the Sit to Stand movement. The purpose of the movement is to evaluate the lower-extremities strength and endurance of individual. Different are the examples among this functional performance tests based on Sit to stand motion that can be utilized to screen older adults, also at risk of falling (Website CDC STEADI 2020). A copy of the form utilized for this thesis can be found in Appendix 2.

The Five-Time Sit to stand is one of these screening tools, which records the total time request to complete five sitting to standing repetitions. This appraisal tool can significantly foresee recurrent falls in community living older adults (Applebaum et al. 2017). Additionally, the impossibility to accomplish the Five-Time Sitting to Stand test, according to Zhang et al. (2014), has considered a relevant predictor of ADL and IADL related disability.

The 30 Second Sit to Stand Test is another valid way to measure the lower-body strength and endurance of individual. Therefore, it is also a reliable instrument to forecast the risk of potential injury among elderly (Zhuang et al. 2014, Phelan et al. 2015). To overtake the "floor effect" given by the inability for some older adults to complete the five repetitions, and consequently not having a score; others test such as the mentioned 30 Second Sit to Stand Test has been developed (Website of Sralab 2020). The benefit of this test is that it can also be used with older adults having reasonable to severe mobility limitations (Applebaum et al. 2017).

The participants were asked to sit in a standard chair, with seat height about 43 cm, with their arms crossed over the chest. The subject is seated on the chair with straight back and feet about shoulder width apart placed on the floor. The participant is then encouraged to execute as many full stands as possible within 30 seconds (Website of CDC STEADI 2020).

According to the literature available, 30-Second Sit to Stand Test is a sensitive tool to predict the likelihood of falls among elderly (Zhuang et al. 2014). In fact, as stated by Phelan et al. (2015), the impossibility to stand up from a chair of knee height without the help of the arms or a score below the reference's values for gender and age, indicates higher chance of fall.

6 FALL PREVENTION INTERVENTION

Fall prevention strategies have incorporated training programs with the aim to decrease the risk of fall by focusing mainly on strength and balance (Chodzko-Zajko et al. 2009). As Gardner (2001) states, muscle weakness and compromised balance are majors risk factors among many falls as well as relative fall injuries for community dwelling elderly. One of the main objects of fall prevention strategies is to develop and prescribe tailored exercise programs. This, with the aim to lower the risk of fall by improving these two components (Gardner 2001).

However, as confirmed by the literature available, deficient health with related disability, and dependency from others, seems not have to be inevitable consequences of aging. In fact, as highlighted by Cadore et al. (2013) elderly who regularly practice healthy lifestyles, including participate in physical exercise, are more prone to be healthy, live independently, and incur fewer health-related costs.

After a critical analysis of the literature available, it is possible to summarize the following guidelines as stated by Costello & Edelstein (2008) in their systematic review. Exercise alone appears to be effective in reducing falls. It should therefore be included in a comprehensive training program combined with muscle strength training, balance training, and/or endurance training for a period of at least three months (Sherrington 2017).

Additionally, there are several fall prevention interventions available for health care providers. These can be delivered in synergy with other specialists and include different components, such as a multifactorial protocol. More specifically, as stated above, these strategies might include physical activity program, medication review, dietary assessment, environment- and behavioral modification (Website of NICE 2020).

This type of interventions, namely multifactorial, are combined with an evaluation of the current medication and vision assessment. Together, with an appropriate referral from a health practitioner, this should be included in a fall screening examination. This kind of fall screening appear to be more effective for older individuals with a previous fall history versus a control group (Sherrington 2017). Correspondingly, home hazard assessment might be necessary, with possible modifications of risk factors. This seems to be beneficial in reducing falls, especially in this targeted group of individuals.

As an alternative, other strategies can be focused on just one single aspect. This aspect is more specifically training and is a part of the so-called exercise program methodology. According to Zaleski et al. (2016), a training program should be individualized and follow in a systematic pattern: Frequency, Intensity, Time, Type, Volume, and Progression, known also as the FITT-VP principle.

Guirguis-Blake et al. (2018) sates that due the significant burden of morbidity related to falls in elderly, it is relevant and necessary to determine which of these interventions targeting fall risk factors have shown to be more beneficial.

According to the literature available, and the limited time given for this bachelor's degree thesis project; the authors of this thesis decided to focus their research mainly on exercise program methodology. This due to the evidence on falls related benefit related to this type of intervention and the correspondent consistency, as stated by Guirguis-Blake et al. (2018).

6.1 Relationship between Physical Activity and Falls

Inactive behavior is amongst others, considered as a key factor responsible for the decrease of daily activity functions. Consequently, this has a negative effect on the equilibrium control as Thomas et al. (2019) states.

However, according to the literature available, many studies support that physical activity might counteract this phenomenon (Fragala 2019).

Exercise is defined by Caspersen et al. (1985) in the way that every movement or physical activity the skeletal muscles make in the body while energy is required. Even though exercise is a subcategory of physical activity, there is still a clear difference between the two. Exercise is intentional movement intended to either improve or maintain physical fitness level or capacity. Exercise is subsequently more structured, planned, and repetitive than just physical activity or movement (Chodzko-Zajko et al. 2009).

Physical activity or physical fitness also contribute a lot to well-being and overall health according to research. Physical fitness can further be divided into five specific components. These components are muscular strength- and endurance fitness, cardiorespiratory fitness, flexibility fitness and body composition (Website of Acefitness 2020)

There is large amount of evidence that suggest that regular physical exercise can reduce the physiological effects of the biological aging process. WHO recommendations states that older adults should do at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. Moreover elderly, with poor mobility, should perform physical activity to enhance balance and prevent falls on 3 or more days per week (World Health Organization 2007). This in relation to an otherwise sedentary lifestyle, that might accelerate degenerative process. For this reason, physical activity might positively effect quality of life and life expectancy (Chodzko-Zajko et al. 2009).

Chodzko-Zajko et al. (2009) also reports in the American College of Sport Medicine, that regular exercise has shown to limit the development and progression of chronic diseases and disabling conditions such as non-communicable diseases.

Sherrington et al. (2019) states that different forms of exercise programs either carried out in group classes or home programs are beneficial. They can be prescribed by a health professional, such as a physiotherapist or a trained exercise leader. Sessions like this might lead to positive outcome on balance and relative falls in elderly. These sessions should be executed in a standing position. The reason for that is that it better improves equilibrium and the ability to perform everyday actions like standing up from a low chair or walking in stairs.

Furthermore, greater relative outcome has been seen in programs with a higher dose of exercise that include drills that challenges balance, rather than simple activity of daily life including walking program as stated by Sherrington et al. (2008).

Interventions focusing on physical activity enhancement to prevent fall incidents in the elderly people living in the community, has showed a positive outcome according to Yeun (2017). These types of programs are necessary due to the drastic impacts of falls. Injuries in relation to falls have effect on mobility and independence among elderly, alongside a decreased quality of life and an increased risk of death due to the secondary complications (Yeun 2017, Sherrington et al. 2017).

It has already been reported in the literature that several different types of exercise interventions have shown a reduction in falls among community-dwelling elderly. Chittrakul et al. (2020) states that most of these programs have focused on strength-, endurance-, flexibility- and balance training. Improvement in biological components and reduced number of falls have been visible after the application of these programs.

Older adults identified at the highest risk for falls seem to benefit from an individually tailored exercise program that is embedded within a larger, multifactorial fall-prevention intervention. Multimodal programs of balance, strength, flexibility, and walking have shown to reduce the risk of both non-injurious and injurious falls (Zaleski et al. 2016).

Therefore, one approach to help reduce these financial and functional costs might be through the encouragement of a Multicomponent Physical Exercise Program (MPEP) among elderly. MPEP is a specific type of training designed to improve endurance, strength, balance and flexibility conducted by an experienced physical trainer (Fragala 2019).

Chodzko-Zajko et al. (2009) showed that older adults benefit significantly both cognitively and psychologically from these types of exercises. According to their study physical activity for elderly should focus on strength and mobility training as well as aerobic training.

As several studies involving older adults have shown, strength training can promote the increment of muscle mass and strength. For this reason, it is therefore rational to presume that stronger muscles, especially in the lower extremities, offer a more stable base of support (Zaleski et al. 2016). A MPEP include resistance training that might be defined as a common type of exercise where participants exercise their muscles against different type resistance. The resistance is progressively raised as the strength and power improves. These trainings are advised to be performed two to three times a week at moderate to high intensity by using different exercise machines, free weights, or elastic bands as claimed by Liu & Latham (2009).

Along with, strength training is a useful tool to not only battle decrease in muscle mass and strength but also physiological weakness, and their effect on ADL. Fragala et al. (2019) have showed that strength training is directly linked to increased levels of physical functioning, flexibility, ability to be independent, long lasting sickness management, happiness, quality of everyday life and healthy life expectancy.

Subsequently, a systematic review available written by El-Khoury et al. (2013), shows sufficient evidence that exercise programs focused on steadiness training improves balance ability. However, also other multicomponent programs based on balance exercises, muscle strength exercises or other form of exercise is beneficial. For example, Tai Chi and flexibility/stretching exercises could also improve physical performance and gait parameters that are strictly connected to the risk of fall. (Zhuang, Huang, Wu & Zhang 2014)

In addition, in relatively active and healthy elderly, Hafström, Malmström, Terdén Fransson & Magnusson showed in 2016, that executing multi joint balance exercises is also beneficial. This because it activates physical reweighting which is one of the factors that affect balance. It challenges and stimulates the vestibulo-cervical, vestibulo-ocular and vestibulo-spinal postural systems.

Also, other exercises where the challenge is to maintain postural stability on unstable surface has been shown to be beneficial for the balance of older adults (Hamed, Bohm, Mersmann & Arampatzis 2018). In fact, reactive balance training on uneven surface is also likely to increase muscle strength. The sensory processing of information also improves within the motor system in unexpected and isometric balance tasks. This improvement will obviously transfer to everyday life activities and will therefore decrease the risk of a fall in an older adult (Fragala 2019).

There is also evidence that different kinds of interventions like gait and functional exercise, strength training, rather than flexibility and endurance training lead to improvement in reaction time. And on top of that also overall coordination with direct consequence on physical performance as well as cognitive functions (Fragala 2019). As stated by El-Khoury et al. (2013) exercise might decrease the probability of fall due to the beneficial effect on cognitive functioning and the speed of protective reaction. Reaction like in quickly reaching or grabbing nearby objects to avoid a fall. Furthermore, a better capacity of absorption of soft tissue and more specifically muscle, might decrease the force of impact on the body, decreasing the severity of the resulting trauma.

Moreover, in a meta-analysis from 2013 by El-Khoury et al. included results from 17 trials with a total of 4305 people taking part; four different categories of falls were recognized. The four categories were all injurious falls, falls resulting in medical care, severe injurious falls and falls resulting in fractures. In every category physical activity and exercise had a positive effect. In other words, exercise programs that are created to prevent falls in older people also seem to protect against injuries caused by falls. Falls causing the need for medical care also decrease due to comparable exercise programs. Every fall that is prevented may have a huge impact on the person and his or her quality of life (El-Khoury et al. 2013).

Even though, the possible injury would be minor or with no medical care needed, a fall can result in social separation, reduced self-confidence and limited activity for the future (Sherrington et al. 2017).

Limited physical activity is very dangerous since it not only speeds up the process of even more functional decline, it also increases the risk of the person not being able to live at home and having to move to a nursing home according to El-Khoury et al. (2013).

Strength and balance training programs might be a new concept for many elderlies, therefore, Gardner (2001) states that it is fundamental that participants can confidentially perform these exercises, which meet their physical capabilities, and so that they understand the benefits of them. With exercise it is possible to enhance many aspects of health and quality of life, as widely reported by the authors of this thesis. However, it is important to consider this for individuals with a higher risk of fall, higher amount of physical activity may result in a greater risk of falling due to increased exposure to environmental hazards too. Moreover, as stated by Rubenstein et al. (2000), the overall fall frequency could not change due to the increased exposure to risk factors performing regular physical activity within this particular population.

According to the official guidelines of ACSM/AHA different balance exercises are currently recommended. This for people who fall often, or for people who have reduced mobility. At the moment, there is no references regarding intensity, frequency or type of balance exercises for elderly. The reason for this being that appropriate evidence is absent and consequently more research is still essential. Despite the absence of evidence, the ACSM Exercise Prescription Guidelines still recommend exercises that contain the following: Postures where the base of support can be progressively decreased such as exercises like two leg stand, semi- and tandem stand, and one leg stand. Dynamic exercises that challenge to control the center of mass like circle turns and/or tandem walk or walking over difficult terrain. Additionally, drills that overload postural muscle groups, including toe- and heel stands. Beside this, performing task or movement with decreased sensory input for instance exercising with closed eyes (Chodzko-Zajko 2009).

Another Cochrane review aimed to analyze the effect of strength training on physical function among elderly. This review concluded that it is an appropriate intervention for older adults who want to improve the performance of activities of daily living (Mangione, Miller & Naughton 2010).

More precisely, progressive strength training should be prescribed two to three times per week in order to reduce physical disability and improve some functional abilities, such as gait speed and time needed to stand up from a chair. Cadore et al. (2013) advise 3 sets of 8 to 12 repetitions and an intensity starting at 20%–30% and progressing to 80% of 1RM. This training load may be well tolerated by frail subjects. Although it has been shown to have a positive effect on both gait and gains in muscle strength, this kind of training shows its largest effect in enhancing strength. Additionally, Cadore et al. (2013) states in systematic review, that overall positive outcome on physiological components, due adaptation, might occur among elderly for resistance training programs that are performed 3 times a week.

Lastly, according to the evidence no subgroup or analysis underlined that strength training was particularly negative for elderly. However, adverse events might occur typically including joint and muscle pain as reported by Mangione, Miller & Naughton (2010).

In conclusion, the above studies included in this literature review show that exercise programs can affect in a positive manner, physical components such as: endurance, strength, balance and flexibility (Fragala 2019).These outcomes analyzed by a systematic review by Cadore et al. (2013), shown that the effect of exercise on risk of fall decrease in the incidence of falls ranged from 22% to 58%.

Due to the fact that this type of training stimulates several components, including balance, cardiorespiratory fitness and obviously strength, it seems to lead to a greater overall enhancement of physical components as highlighted from Cadore et al. (2013).

Although, there is no gold standard for determining the effectiveness of multicomponent exercise and physical activity programs for older adults, these strategies might lead to a decrease of falls in community dwelling elderly as claimed by Rubenstein et al. (2000).

7 TARGET GROUP

The clients participating in this bachelor thesis project were all individuals over 60 years old, living in the region of Satakunta, Finland. The participants were recruited for eligibility screening by advertisements posted in the gym Fittori Oy in Mikkola. All potential candidates gathered a thorough explanation of the suggested study, its potential benefits, length of the committed expected time and possible risks.

7.1 Inclusion criteria

Apart from being over 60 years old, all potential participants were required to fill in a Fall Risk Screening Tool questioner, namely “Stay Independent Brochure”. This Brochure (SIB) that include 12 questions, is a widely used for fall-risk self-assessment appraisal. It is also a part of the Stopping Elderly Accident, Deaths & Injuries (STEADI) program in the USA (Website of CDC STEADI 2020). A copy of the questionnaire is available in Appendix 4. Practically the participants in the study had to answer yes to at least one of the following questions:

1) Do you feel unsteady when standing or walking?
2) Are you worries about falling?
3) Have your fallen in past year?

In fact, as stated by Eckstrom et al. (2017) these questions focus on two of the main risk factors for falling, namely history of falls and gait/ strength/balance. In addition to this, fear of falling was also selected since it has been shown to be related to gait issues even in the absence of previous falls.

The data collected show that two out of the seven participants had a history of falling during the one-year period prior to baseline testing. Five out of seven felt unsteady during walking, and the totality of the participants expressed concern about falling.

The description of the participants results can be seen in Figure 3.

Result Algorithm for Fall Risk Screening, Assessment	Freq.	%
I Have fallen in the past year	2	29
Sometimes I feel unsteady when I am walking	5	71
I am worried about falling	7	100
Total	14	200
N:	7	

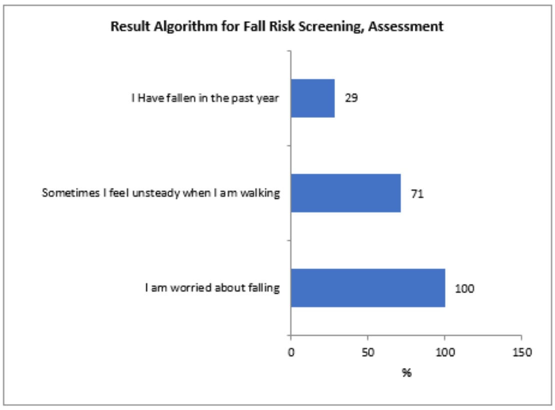


Fig.3: Result of inclusion/exclusion criteria.

7.2 Exclusion Criteria

To minimize the possible risk of potential injuries or other issues, participants were excluded if they needed assistive device for walking or had known medical pathologies which could affect the safety of the study project. Moreover, exclusion criteria were severe cardiac, pulmonary, musculoskeletal disorders or pathologic states associated with a high fall risk (i.e., neurologic disorders). Furthermore, physiological disturbance that prevented vigorous exercise or affected vestibular function were included in the exclusion criteria. All the participants have been required to sign an informed consent and liability waiver released before the beginning of the process. A copy of this form can be found in Appendix 5

7.3 Subjects

Twelve potential applicants were considered for the study. Three potential participants declined to participate. A total of nine participants met the criteria and were invited to take part in the intervention group and the relative MPEP. However, two participants were not able to attend the second assessment on 17^{th} August 2020, due to other commitments. Therefore, only seven participants were analyzed, whom ultimate the whole program.

This is illustrated in Figure 4, Thesis implementation process.

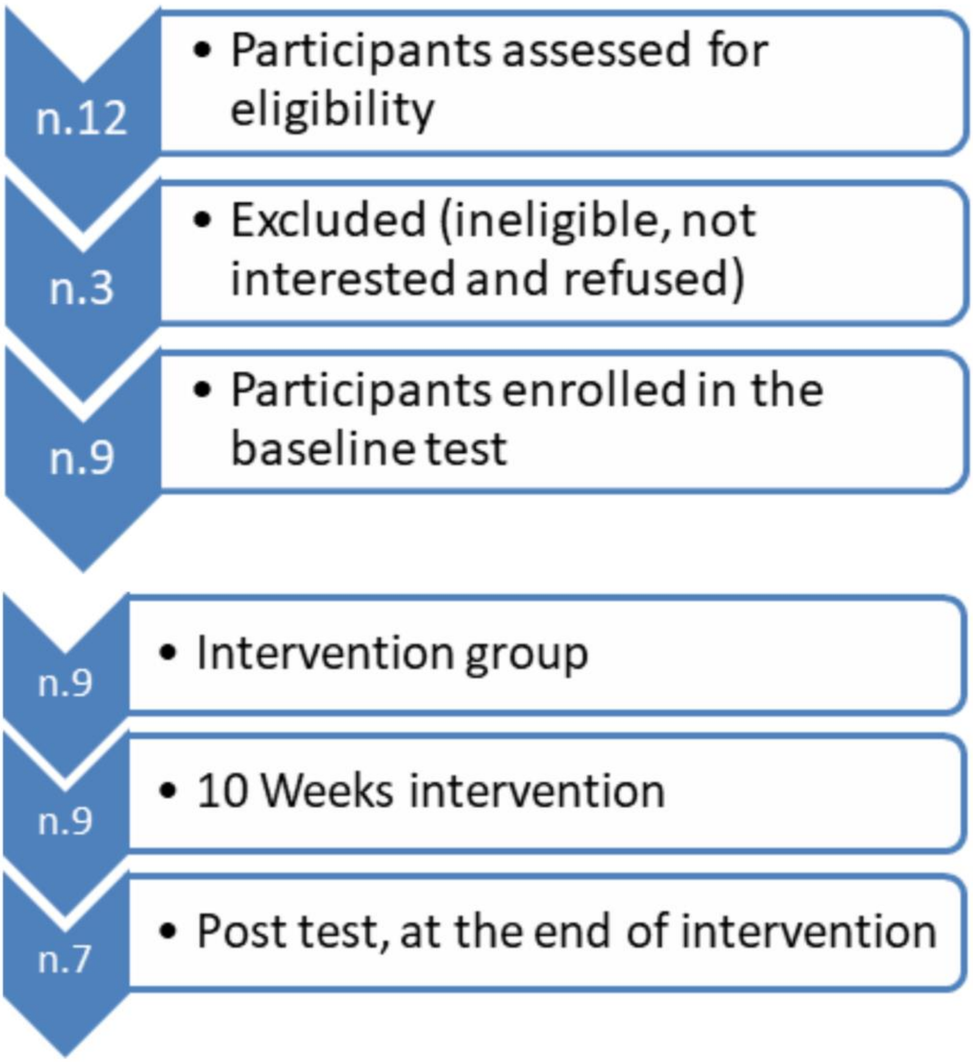


Fig. 4: Thesis Process/Implementation process.

Before the intervention started the authors of this thesis explained the project and the consent form to each participant. All participants gave their written informed consent to the authors of the study. Participants in the intervention group were required to undergo a MPEP carried out for one hour, two days per week for ten weeks. Demographics of the participants are shown in Figure 5.

Variable	Freq.	Average	Median	Standard Deviation	Min	Lower Quartile	Upper Quartile	Max
Age	7	68,57	69,00	5,13	62,00	64,50	72,00	76,00

Gender

	Freq.	%	Cum. freq.	Cum-%
Female	5	71	5	71
Male	2	29	7	100
Total	7	100	7	100

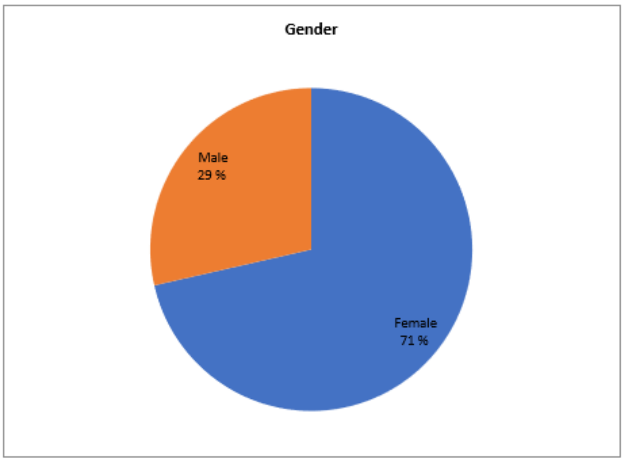


Fig.5: Result demographic of participants.

8 THESIS PROCESS AND METHODS

Studies were identified by searching the electronic databases Medline, PubMed, Embase, Proquest, CINAHL, Cochrane Central Register of Controlled Trials, WHO guideline, article of journals with a strong focus relevant to the topic and other relevant systematic reviews.

The authors of this thesis focused their research on sources published from January 1, 2000, to August 30, 2020.

In addition, the authors of this thesis had identified publication from relative citations in order to find supplementary studies.

Key search terms included: fall, fall prevention, elder, balance, community dwelling, exercise program, resistance training in frail, endurance training in frail, exercise training in elderly, multi-component exercise interventions, muscle power in elderly, muscle strength in elderly.

The authors of this thesis scanned and analyzed the literature available with the aim to have a better understanding of the evidence. And therefore, formulate an accurate and evidence-based outcome, although aware of the limitation by the time available to conduct this research.

8.1 Study design

The research method for this thesis was quantitative. Quantitative research is a broad area of scientific methods. Quantitative research enables to describe and interpret object statistic with numbers. Furthermore, this research focuses on several modes of classification, exploration of causality, comparison, and explanations of phenomena through numeric variables. Quantitative research uses different types of computational and statistical methods of analysis (Website of Jyväskylän Yliopiston Koppa 2020). Moreover, the object of the research was the classification and comparison of the data collected by the assessment done with the tests performed throughout the intervention.

These components were evaluated by performing the following three tests: The Timed Up and Go test (TUG), the 30-second Chair Stand (30sCS) and the 4-stage Balance Test (4SBT).

The thesis was designed as “uncontrolled trial” or “before and after studies”. This term, as stated by Littlewood & May (2013), refers to an intervention without a control group, since there is only one experimental group and data are collected before and after experimental trial. This type of study is commonly used as a feasibility study and require typically a smaller number of participants. In fact, a feature of this type of investigation is what enables someone to evaluate how feasible it would be to undertake a randomized controlled trial. That would obviously require more time and resources.

Our sample group consists of the results of seven participants, which should be considered a small amount of data. This collection of data cannot be considered to follow a specific distribution with defined parameters. Therefore, as stated by Salkind (2010), the nonparametric method is a valid option to obtain results although does not include as many assumptions as the parametric method. As a nonparametric method we have used the Wilcoxon signed rank test. It compares the difference between two groups in paired samples and its equivalent in the parametric method is the paired sample t test. As claimed by Rosner (2006) this rank test is comparing medians and the results get positive or negative signs for their ranks, based on if they have negative or positive differences. In addition, to be statistically meaningful the result must be lower than 0,05 compared to the null hypothesis.

8.2 Exercise program for Implementation

The authors of this thesis provided an evidence-based training program based on the literature available. The training program was then executed by the elderly participants of the study, together with the authors and the supervisor physiotherapist.

The program included different multi joint exercises in each session. The exercises were chosen to mimic tasks of activity of daily living and classified as functional exercises or strength training (Sherrington 2017, Fragala 2019).

Amongst other forms of physical activity, strength training is intended to increase muscular fitness, either in terms of endurance, power, size and/or strength. This by training a muscle group or a single muscle against an outside resistance (Website of Trekeducation 2020).
This type of training leads to the muscle(s) contracting. The resistance can basically be anything including the own bodyweight.

The practical intervention took part twice a week, Mondays and Fridays for ten weeks in total executed between 8th June and 17th August 2020. Each session had a length of approximately one hour. The sessions were delivered in the gym Fittori OY located in Mikkola (Satakunta).

The authors of the thesis collaborated with their physiotherapist supervisor and performed a battery of tests both before and after the intervention. The tests that were performed included the Timed Up & Go test, the 30-second Chair Stand test and the 4-stage Balance Test. This, with the aim to analyze the possible decrease of the likelihood of falling for the participants. Hence, measuring the physical performance associated with the risk of falls such as: balance, muscle strength and gait among older people.

All participants in this study had comparable ability at baseline. To ensure that everyone exercised correctly and safely, they were trained not only under the guidance of the authors of this thesis but also with an experienced physiotherapist named Petteri Joukamaa. Joukamaa, who supervised the whole process has over 20 years of experience as a physiotherapist. He also one of the owners of the gym Fittori Oy where the training sessions were delivered.This plan was designed based on the components of a fall risk assessment and literature concerning exercise interventions for fall prevention. The MPEP consisted of four parts: warm up, proprioceptive balance training, muscle strength training and cool down.

Each session started with a 10-minute warm-up when the participants freely could use the rowing machine, ski ergometer or the assault bike. The participants were also given the option to just walk or jog. The warm-up also included both dynamic and static stretching for upper and lower limbs. On top of that also joint rotation for the neck, hip, knee, shoulder and ankle was included.

This was followed by 15-20 minutes of different dynamic balance drills including exercises, such as tandem foot standing, multi-directional weight lifts, heel–toe walking, line walking, stepping practice, standing on one leg while catching/throwing a ball, drills on altering the base of support and weight transfers (from one leg to the other). As stated by Cadore et al. (2013) this type of training is conventionally included in multi-component exercise program. It should progress from easy to more difficult exercises, with the physiological intensity of training increasing over time.

The strength training part lasted about 25 minutes and targeted the whole body, with focus on the lower limbs. Furthermore, the prescribed session delivered, to optimize functional capacity, included exercises in which the participants' own body weight was used as resistance. The exercises simulated usual daily activities (such as the ‘‘sit to stand’’ exercise), as highlighted by Cadore et al. (2013). Each session covered up to three multi joint exercises, including weight, bodyweight or resistance bands. In fact, the effectiveness of this type of training mode for improving the flexibility and balance of the elderly people, living in the community. It has been shown to increase their steadiness according to Yeun (2017).

After this, participants had a relative short break combined with water intake, with the aim to decrease heart rate. Ultimately a flexibility/stretching routine of ten minutes was included at the end of each training as part of cool-down.
This with the aim to release muscle tension, decrease soreness and potentially reduce the risk of injury of the major muscles as stated by Reddy & Alahmari (2016).
According to the literature available, if done regularly, this sort of routine seems to also have positive effects in enhancing balance in the geriatric population.

All the exercises planned were executed in relation to the equipment available, with the primary aim to minimize the risk of accidents for the participants. Furthermore, the authors planned a variety of different exercises/movements for each session. This to maintain a healthy and challenging exercise regimen among the participants throughout the whole intervention. Figure 6 illustrate an example of exercises used to plan a training session.

Lower extremity strengthening	Hamstring flexion Leg extension (seated) Knee lifts Hip adduction and abduction Ankle point and flex Ankle circles Bottom squeeze Chair squat Wall squat Standing side leg raise
Upper body strengthening	Biceps curl Triceps extension Lateral raise Front raise Rear raise Chest press Rotator fly Forearm curl Shoulder-extension pullback Internal-rotator raises
Balance exercises	Single-leg balance Static sitting on a ball Dynamic sitting on a ball Side twists Overhead side bends

Fig.6: Example of exercises used to plan a training session.

The authors of the thesis have analyzed the results of three tests namely: The Timed Up & Go test (TUG), the 30-second Chair Stand (30sCS) test and the 4-stage Balance Test (4SBT), before and after a 10 weeks MPEP training period.

This, with the aim to assess the physical performance associated with the risk of falls such as: balance, muscle strength and gait among older people.

8.3 Attendance

The trial sample for the thesis comprised moderately active (i.e., home and yard tasks, recreative hiking), community dwelling elderly from the area of Satakunta, Finland. Participants were recruited trough public service announcements published in the local gym Fittori Oy in Mikkola (Satakunta). People 60 years of age and older were eligible to participate according to the inclusion criteria.

12 potential applicants were considered for the study, 3 potential participants declined to participate, 9 individual completed baseline testing, but two participants were not able to attend the second assessment on 17th August, due to other commitments. Therefore, only 7 participants were analyzed whom ultimate the whole program.

The residual seven participants attended 81% of the total possible workouts (114/140 sessions), and data were collected from all at each of the two data collection points on 8th June 2020 and 17th August 2020.

The itemized results for attendance are presented below in Figure 7.

Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		Week 7		Week 8		Week 9		Week 10			
08-Jun	12-Jun	15-Jun	22-Jun	26-Jun	29-Jun	03-Jul	06-Jul	10-Jul	13-Jul	17-Jul	20-Jul	24-Jul	27-Jul	31-Jul	03-Aug	07-Aug	10-Aug	14-Aug	17-Aug	Total	%
1	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	18	90 %
1	1	1			1	1		1	1			1	1	1	1	1	1	1	1	15	75 %
1	1			1		1	1		1	1	1		1	1	1	1	1		1	14	70 %
1	1	1			1	1		1	1			1	1	1	1	1	1	1	1	15	75 %
1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1		1	1	18	90 %
1	1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	16	80 %
1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1	18	90 %
																Total Group Attendance				114	81 %

Fig.7: Results of attendance.

8.4 4-Stage Balance Test

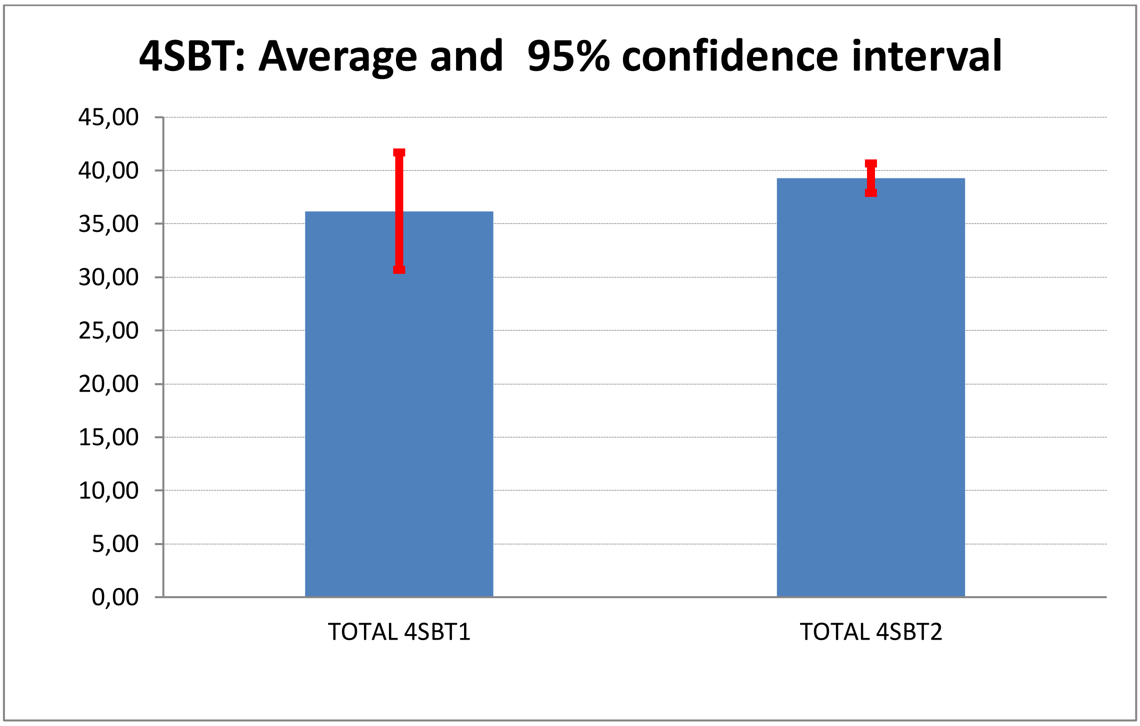
Static balance was evaluated by recording how long the subjects could remain standing in four positions that get progressively harder to maintain, so called 4-stage balance test.

This assessment reliable for testing health related fitness, is useful in explaining other variables of importance such as frailty and self-sufficiency in activities of daily living and gait performance. According to the literature available, subjects who are not able to stand on one limb for five second, have 2.1 times the risk of incurring in a fall (Springer 2007).

Participants were asked to stand in the four positions instructed by the physiotherapist. These positions were namely: parallel, semi-tandem, tandem and single-leg stand. Each subject was asked to focus on a spot on the wall at eye level in front of them for the duration of the test. Furthermore, the subjects were instructed to cross their arms over their chest. The physiotherapist used a stopwatch to measure the amount of time the subject was able to stand on the given stance. Time started when the physiotherapist gave the command to begin.

Time ended when the subject either: used his arms (i.e., uncrossed arms), used the raised foot or moved from the initial stance position (moved it toward or away from the standing limb or touched the floor), moved the weight-bearing foot to maintain his balance (i.e., rotated foot on the ground) or a maximum of 10 seconds had elapsed.

At the initial test on 8thJune 2020 four participants completed all the four stages of the test, two participants completed the first three stages and one participant completed only the first two. At the final test on 17th August 2020, only two participants were not able to complete all the four stages. The remaining participants were able to complete the first three stages. None of the participants showed a decrease in time, however three participants were able to stand in the one leg stand position for longer. One improved from 5,46 seconds to 9,00 seconds, the second one improved from 0 seconds to 10 seconds and the third one improved from 3,91 seconds to 6,00 seconds. The average improvement for these three participants was of 23% with a range between 6% and 67%.
The results of 4SBT test are illustrated in Figure 8.



Variable	*Freq.*	*Average*	*Median*	*Stand-ard Devia-tion*	*Min*	*Lower Quartile*	*Upper Quartile*	*Max*	*Confidence Limit Low (95%)*	*Confidence Limit Up (95%)*
TOTAL 4SBT1	7	36,20	40,00	5,95	24,00	34,69	40,00	40,00	30,69	41,70
TOTAL 4SBT2	7	39,29	40,00	1,50	36,00	39,50	40,00	40,00	37,90	40,67

Fig. 8: Result of the 4SBT.

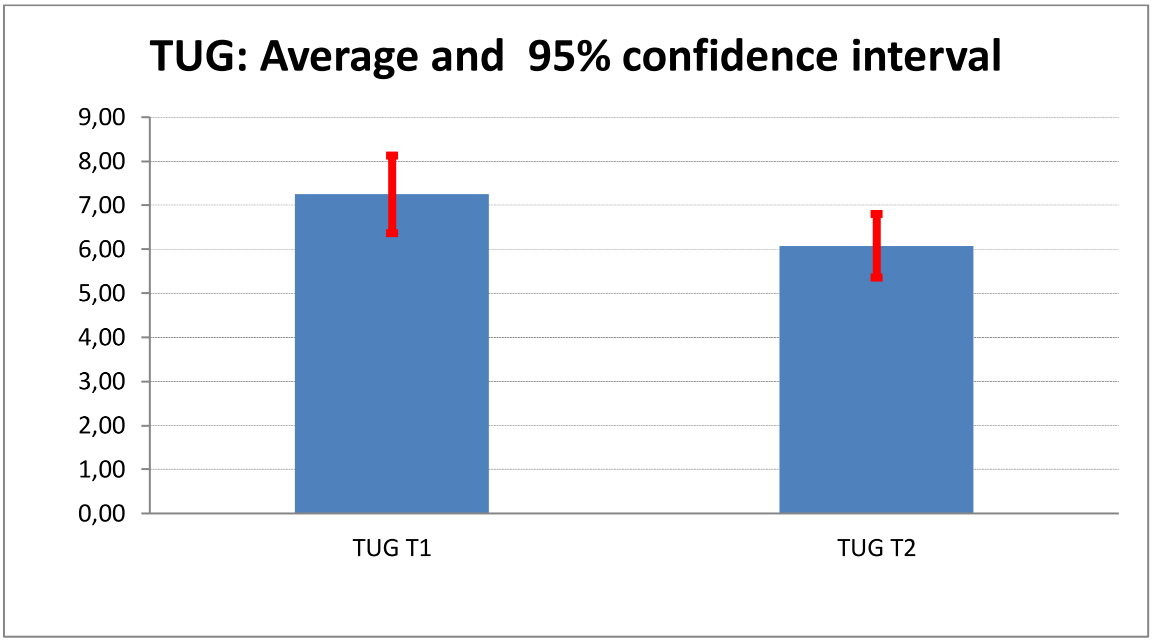
8.5 Timed Up and Go Test

All the participants improved their performance in the TUG test. This is illustrated in Figure 9. Results of the TUG test suggested that there was significant improvement in the mobility and balance required for the performance of basic activities of daily living. In fact, this test consists of different tasks (i.e., moving from sitting to standing, walking, turning and sitting down) whose importance for subjects' everyday life is obvious.

The results suggest that a MPEP held twice a week for ten weeks might improve walking speed, which is a risk factor associated with falling.In fact, the mean value of the time used to perform this test for the group dropped from 7,25 seconds to 6,08 seconds. The relative improvement in percentage is 16,1%.This improvement is within the mean 4% to 50% found in similar gait performance assessment, this according to a systematic review about the effect of exercise done by Cadore et al. (2013).

Additionally, in the initial measurements the median was 7,14 seconds. The fastest time was 6,31 seconds and the slowest time was 7,70 seconds. In the final measurements the median was 6,22 seconds, the fastest time was 4,81 seconds and the slowest time was 6,51 seconds. When comparing initial and final measurements, the median was reduced by 0,92 seconds, the mean value reduced by 1,17 seconds and the standard deviation reduced by 0,17. There was statistically significant improvement ($p = 0,022 < 0,05$). The results of the TUG test are illustrated in Figure 9.

Furthermore, according to a meta-analysis done in 2006 by Bohannon, the TUG results are worse than average if they exceed: 9.0 seconds for 60- to 69-year-olds, 10.2 seconds for 70- to 79-year-olds, and 12.7 seconds for individuals 80- to 99-year-old. Individuals with slow times recorded during this test, may warrant interventions directed at improving their strength, balance, and/or mobility. The gathered data from the participants of this study trial were all within these reference values.



Variable	*Freq.*	*Average*	*Median*	*Standard Deviation*	*Min*	*Lower Quartile*	*Upper Quartile*	*Max*	*Confidence Limit Low (95%)*	*Confidence Limit Up (95%)*
TUG T1	7	7,25	7,14	0,95	6,31	6,46	7,70	8,95	6,36	8,13
TUG T2	7	6,08	6,22	0,78	4,81	5,66	6,51	7,20	5,36	6,80

Fig. 9: Results of the TUG Test.

8.6 30-Second Chair Stand Test

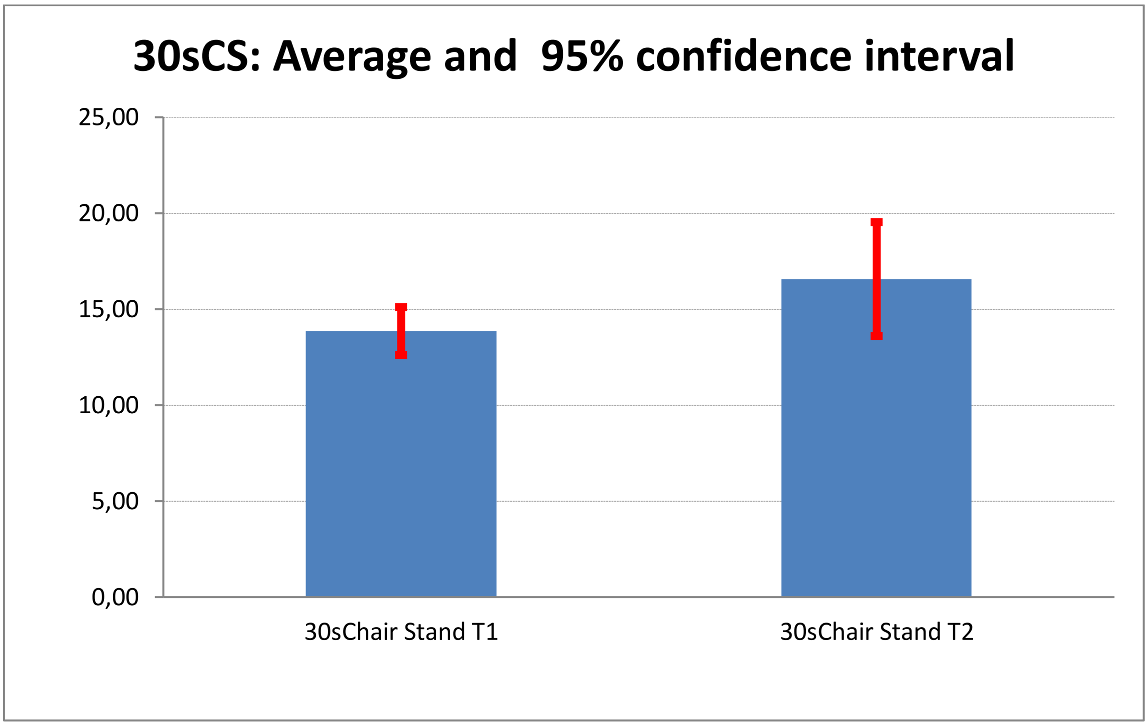
The 30-second Chair Stand (30SCS) test was measured by counting the number of times participants were able to stand up and sit down within 30 seconds. This on an armless chair with seat about 43 cm high. The same chair was used for all subjects during both test sessions. A wall supported the back of the chair, and all the testees kept their arms folded across their chests throughout the performance of the test.

Figure 10 shows the 30sCS test scores and standard deviation of the intervention group before and after training protocol implementation. The 30sSCS performance improved for the majority or the participants, with a mean increase of 19,6%.

In the initial measurements the median was 14 repetitions, the mean value was 13,86. The lowest score was 12 and the highest score was 16. In the final measurements the median was 18 repetitions, the mean value was 16,57. The lowest score was 13 and the highest score was 21. When comparing initial and final measurements, the median increased by 4 repetitions points, the mean value increased by 2,71 meanwhile the standard deviation was reduced 1,86.

The increase of result in 30sCS was statistically significant ($p = 0{,}035 \leq 0{,}05$).
The results showed significant evidence of an improvement in lower limb muscle strength, especially among muscle groups responsible in hip extension, knee extension, and ankle plantar flexion. A similar Randomized control trial held in 2000 included three weekly sessions of a strength exercise program. The sessions lasted for 90 minutes and were held for a period of twelve weeks. The result of the 30sCS test showed that subjects increased their average number of repetitions by 23% compared to 4% for controls (Rubenstein et al. 2000).

There is strong evidence that the 30sCS test has good test–retest reliability and provides a safe and effective method to test lower-body strength in older populations.
Additionally, Zhuang et al. (2014) reported a 54.7% increase in the 30sCS scores which are consistent in relation to a similar previous study that found a 66% increase after 10 weeks of lower-body resistance training. The results gathered from this thesis found similarities with two other research groups which found 13.5% and 20% improvements respectively in the 30sCS test. This after a similar period of physical exercise intervention (Zhuang et al. 2014, Cao 2007, Islam 2004).



Variable	Freq.	Average	Median	Standard Deviation	Min	Lower Quartile	Upper Quartile	Max	Confidence Limit Low (95%)	Confidence Limit Up (95%)
30sCS T1	7	13,86	14,00	1,35	12,00	13,00	14,50	16,00	12,61	15,10
30sCS T2	7	16,57	18,00	3,21	13,00	13,50	18,50	21,00	13,61	19,54

Fig.10: Results of the 30sCS Test.

9 CONCLUSION

The aim of this thesis was to evaluate the effectiveness of a MPEP held twice a week for ten weeks on the physical performance of group of elderly over the age of 60. The authors wanted to look at the relationship between this specific type of training and the changes on physiological components like dynamic and static balance, as well as lower limb strength before and after the training period.

The results were gathered from 7 participants using the 4SBT test, TUG test, and the 30sCS test as measurement methods. There was statistically significant improvement in the results of the TUG and the 30sCS. The 4SBT test showed no statistically significant improvement. The results showed that a ten-week lasting MPEP group-based training program may have positive effects on the balance of independently living elderly people. This due the improvement in their static and dynamic balance as well as the improvement in strength in the lower limbs. Hence, these results suggest that the MPEP that together include endurance, strength, balance, and flexibility training might be an effective approach to ameliorate the risk factors for falls and to promote safer locomotion in elderly community dwelling.

The present thesis has also confirmed previous research outcomes, underlying that this type of physical exercise might lead to an improvement in fall-related physical performances including strength and gait parameters.

10 DISCUSSION

The aim of this thesis was to determine the effects of a MPEP carried out for 1 hour, 2 days per week for ten weeks. The effect was evaluated with measurement tools associated with the risk of fall, such as: balance, muscle strength and gait performance in a specific population of elderly with frailty and pre frailty.
To be consistent with the above statement in this thesis, the authors considered individuals aged 60 year and older being suitable for the study design and implementation (Chodzko-Zajko et al. 2009).

The two authors were aware of the complex relationship between physiological changes associated with aging and falls. More precisely, decline in skeletal muscle mass, strength, and function, even in the absence of chronic disease, decrease physiologic resilience and increase vulnerability to potential negative events.

However, according to the results gathered there might be evidence that a ten-week MPEP improve fall-related physical performance and gait parameters, showing a potential reduction in risk of falls among the participants of the study.

These outcomes are consistent with previous research, which denoted that training intervention, including MPEP, has positive effects on developing physical performance and therefore potentially reduce risk of fall among the frail and pre-frail elderly living in community. Furthermore, these findings are critically important because even the modest improvements in strength and mobility can have a major impact on an individual's ability to remain independent, especially among dwelling older persons.

Primary strengths of this thesis were, according to the authors, its beneficial outcomes and prospective for replicability, moreover, shown the following implication for practice.

First, the development of qualitative partners, in this case the local gym Fittori Oy in Mikkola (Satakunta) was vital for the success of the whole program. In fact, a reliable partner who facilitated the recruitment of participants, and offered a suitable exercise space was a key factor. The authors of this thesis assumed that their clients felt more willing to participate due to the organized and comfortable facility provided.

Second, although the supervision of an experienced physiotherapist named Petteri Joukamaa was crucial to the accomplishment of the whole planning and intervention. The authors of this thesis were well suited to assist and lead exercises during each session. Third, because of the relevance of the topic, namely fall prevention, this pilot study reinforced the importance of starting to work on balance exercises and relative fall risk in advance.
We noted an overall improvement among all the group members. Therefore, implementing this kind of intervention at this stage among pre-frail elderly, living in a community, might reduce fall risk and delay the onset of falls and reduce the overall number of falls and relative expenses.

However, the authors were aware of several weaknesses, which confer implications for future eventual research. First, the small number of participants might have affected the results and underestimate the significant change among them. Therefore, for further potential studies a larger population and equal number of males and females might be recommended.

In fact, it could be easier to better validate findings of this community case study and advance the overall literature and knowledge within this field with an higher number of people.

Additionally, the subjects involved in this thesis process were healthy and all willing to undertake the training program. This selection of active, high-level functioning participants with already a good baseline characteristic would tend, according to the authors, to limit the possible improvements from the MPEP. Similar or greater improvements might be achievable in a population of less-active group of elderly.

Second, the length of this trial was relative short, only 10 weeks. Reproduction of a similar intervention over a longer period could show more significant changes. Moreover, a wider timeframe would allow the researcher/s to also collect eventual follow-up data after the initial intervention. These observations could highlight if the effects of the trial are maintained over time and gather more tangible outcomes, that can be seen, such as: number of falls, relative injury and medical costs.

Third limitation of this study is the lack of a control group. Due to lack of time and relative implementation, this prevents us from studying the eventual further effect of our intervention end increase the overall effectiveness of the research. Therefore, the authors of this thesis acknowledge the fact that proper clinical relevance must be demonstrated definitively via further randomized controlled trials in high-risk older populations.

In addition, considering initial and final measurements the authors of this thesis do not know how external factors outside the training program such an active lifestyle might have affected the results. Moreover, other basic sensitive information such as height and weight rather than cognitive function were not measured in this study.

Several studies have found that older subjects could undertake resistance training and achieve several physiological benefits. The findings of this bachelor’s degree thesis corroborate with the interventions that include strength training among elderly above the age 60 years. This in relation to MPEP carried out for 1 hour, 2 days per week for 10 weeks.

The general improvement in balance measures can be explained as greater tolerance of instability, mainly due to increased resistance and overall strength in the lower extremity muscles. The training delivered in the present thesis project resulted in modest strength gains of 19,6% among the group.

However, these improvements in strength may not necessarily equate to improvements in function of activities of daily living. Consequently, optimal approaches which required multi-disciplinary cooperation in evaluation and relative interventions, tailored exercise, attention to co-existing medical conditions and environmental assessment or potential hazard is required.

Although this thesis did not assess psychological components, most of the participants of the training group showed profound gratitude for the valuable feature of the exercise. The intervention may also lead to a decrease in the fear of falling, depression, and an increase in their quality of life. In fact, the whole group seemed to be affected by an improvement on the psychological level, this because of the effect the resistance training might have provided. Especially due to the exercise was performed in group since participants became more engaged with the instructors and their fellow participants.

This seems to confirm what was stated by, Zaleski et al. (2016) where a group-based training was been more efficient for long-term adhesion rather than other forms of exercises such as individual home-based ones.
Furthermore, this type of class exercise strategies that beside physical activity components also include, education, positive social support, and behavior theories to promote and build self-efficacy. These methods are vital to enhance exercise adherence among elderly and optimize mental health through physical fitness, especially due the rapid increased rates of social phenomena like isolation and possible depression (Chodzko-Zajko 2009).

In fact, some of the participants felt that they were more energetic and in a better mood thanks to the intervention. Some experienced decrease of pain in their joints, a more relaxed feeling and better concentration abilities. Participants also expressed that their overall balance had enhance motivation and courage to exercise more often and to be more physically active.

In the field of physiotherapy, balance, accidental falls, and fear of falling have been studied widely. The authors of this thesis managed to design and implement a MPEP balance training program, which was both challenging and safe.
It was based on the principles of balance training for the elderly and the emphasis was put on multitask exercises.

Promising results have been obtained, however, the relationship between exercise and risk of falls remains unclear.
Due to the insufficient amount of data collected, further high methodological quality research is required.
In summary, it is not possible to draw any general conclusion to define specific exercise training protocol to prevent falls in a specific population of elderly with frailty and pre frailty.

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ASSESSMENT

Timed Up & Go (TUG)

Purpose: To assess mobility

Equipment: A stopwatch

Directions: Patients wear their regular footwear and can use a walking aid, if needed. Begin by having the patient sit back in a standard arm chair and identify a line 3 meters, or 10 feet away, on the floor.

Patient ______

Date ______

Time ______ ☐ AM ☐ PM

① **Instruct the patient:**

NOTE: Always stay by the patient for safety.

When I say "Go," I want you to:

1. Stand up from the chair.
2. Walk to the line on the floor at your normal pace.
3. Turn.
4. Walk back to the chair at your normal pace.
5. Sit down again.

② **On the word "Go," begin timing.**

③ **Stop timing after patient sits back down.**

④ **Record time.**

Time in Seconds: ______

An older adult who takes ≥12 seconds to complete the TUG is at risk for falling.

OBSERVATIONS

Observe the patient's postural stability, gait, stride length, and sway.

Check all that apply:

- ☐ Slow tentative pace
- ☐ Loss of balance
- ☐ Short strides
- ☐ Little or no arm swing
- ☐ Steadying self on walls
- ☐ Shuffling
- ☐ En bloc turning
- ☐ Not using assistive device properly

These changes may signify neurological problems that require further evaluation.

CDC's STEADI tools and resources can help you screen, assess, and intervene to reduce your patient's fall risk. For more information, visit www.cdc.gov/steadi

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2017

STEADI Stopping Elderly Accidents, Deaths & Injuries

ASSESSMENT

30-Second Chair Stand

Purpose: To test leg strength and endurance
Equipment: A chair with a straight back without arm rests (seat 17" high), and a stopwatch.

Patient ____________

Date ____________

Time ____________ ☐AM ☐PM

① **Instruct the patient:**

NOTE: Stand next to the patient for safety.

1. Sit in the middle of the chair.
2. Place your hands on the opposite shoulder crossed, at the wrists.
3. Keep your feet flat on the floor.
4. Keep your back straight, and keep your arms against your chest.
5. On **"Go,"** rise to a full standing position, then sit back down again.
6. Repeat this for 30 seconds.

② **On the word "Go," begin timing.**

If the patient must use his/her arms to stand, stop the test. Record "0" for the number and score.

③ **Count the number of times the patient comes to a full standing position in 30 seconds.**

If the patient is over halfway to a standing position when 30 seconds have elapsed, count it as a stand.

④ **Record the number of times the patient stands in 30 seconds.**

Number: ____________ Score: ____________

SCORING

Chair Stand
Below Average Scores

AGE	MEN	WOMEN
60-64	< 14	< 12
65-69	< 12	< 11
70-74	< 12	< 10
75-79	< 11	< 10
80-84	< 10	< 9
85-89	< 8	< 8
90-94	< 7	< 4

A below average score indicates a risk for falls.

CDC's STEADI tools and resources can help you screen, assess, and intervene to reduce your patient's fall risk. For more information, visit www.cdc.gov/steadi

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APPENDIX 3

ASSESSMENT

The 4-Stage Balance Test

Purpose: To assess static balance

Equipment: A stopwatch

Directions: There are four standing positions that get progressively harder to maintain. You should describe and demonstrate each position to the patient. Then, stand next to the patient, hold their arm, and help them assume the correct position. When the patient is steady, let go, and time how long they can maintain the position, but remain ready to assist the patient if they should lose their balance.

- If the patient can hold a position for 10 seconds without moving their feet or needing support, go on to the next position.
- If not, **STOP** the test.

Patients should not use an assistive device (cane or walker) and they should keep their eyes open.

An older adult who cannot hold the tandem stand for at least 10 seconds is at increased risk of falling. To reduce their risk of falling, you might consider referring them to physical therapy for gait and balance exercises, or refer them to an evidence-based fall prevention program, such as Tai Chi.

APPENDIX 3

ASSESSMENT CONTINUED

The 4-Stage Balance Test

Patient ____________________

Date ____________________

Time ____________________ ☐ AM ☐ PM

Instructions to the patient:

- I'm going to show you four positions.
- Try to stand in each position for 10 seconds.
- You can hold your arms out, or move your body to help keep your balance, but don't move your feet.
- For each position I will say, **"Ready, begin."** Then, I will start timing. After 10 seconds, I will say, **"Stop."**

① **Stand with your feet side-by-side.**	Time: __________seconds
② **Place the instep of one foot so it is touching the big toe of the other foot.**	Time: __________seconds
③ **Tandem stand: Place one foot in front of the other, heel touching toe.**	Time: __________seconds
④ **Stand on one foot.**	Time: __________seconds

Notes:

CDC's STEADI tools and resources can help you screen, assess, and intervene to reduce your patient's fall risk.
For more information, visit www.cdc.gov/steadi

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STEADI Stopping Elderly Accidents, Deaths & Injuries

Four Things You Can Do to Prevent Falls:

① **Speak up.**
Talk openly with your healthcare provider about fall risks and prevention. Ask your doctor or pharmacist to review your medicines.

② **Keep moving.**
Begin an exercise program to improve your leg strength and balance.

③ **Get an annual eye exam.**
Replace eyeglasses as needed.

④ **Make your home safer.**
Remove clutter and tripping hazards.

1 in 4 people 65 and older falls each year.

Learn More

Contact your local community or senior center for information on exercise, fall prevention programs, and options for improving home safety, or visit:

- go.usa.gov/xN9XA
- www.stopfalls.org

For more information, visit www.cdc.gov/steadi

This brochure was produced in collaboration with the following organizations: VA Greater Los Angeles Healthcare System, Geriatric Research Education & Clinical Center (GRECC), and the Fall Prevention Center of Excellence

Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

2017

Stay Independent

Learn more about fall prevention.

STEADI

Check Your Risk for Falling

Circle "Yes" or "No" for each statement below			Why it matters
Yes (2)	No (0)	I have fallen in the past year.	People who have fallen once are likely to fall again.
Yes (2)	No (0)	I use or have been advised to use a cane or walker to get around safely.	People who have been advised to use a cane or walker may already be more likely to fall.
Yes (1)	No (0)	Sometimes I feel unsteady when I am walking.	Unsteadiness or needing support while walking are signs of poor balance.
Yes (1)	No (0)	I steady myself by holding onto furniture when walking at home.	This is also a sign of poor balance.
Yes (1)	No (0)	I am worried about falling.	People who are worried about falling are more likely to fall.
Yes (1)	No (0)	I need to push with my hands to stand up from a chair.	This is a sign of weak leg muscles, a major reason for falling.
Yes (1)	No (0)	I have some trouble stepping up onto a curb.	This is also a sign of weak leg muscles.
Yes (1)	No (0)	I often have to rush to the toilet.	Rushing to the bathroom, especially at night, increases your chance of falling.
Yes (1)	No (0)	I have lost some feeling in my feet.	Numbness in your feet can cause stumbles and lead to falls.
Yes (1)	No (0)	I take medicine that sometimes makes me feel light-headed or more tired than usual.	Side effects from medicines can sometimes increase your chance of falling.
Yes (1)	No (0)	I take medicine to help me sleep or improve my mood.	These medicines can sometimes increase your chance of falling.
Yes (1)	No (0)	I often feel sad or depressed.	Symptoms of depression, such as not feeling well or feeling slowed down, are linked to falls.
Total ______		Add up the number of points for each "yes" answer. If you scored 4 points or more, you may be at risk for falling.	

This checklist was developed by the Greater Los Angeles VA Geriatric Research Education Clinical Center and affiliates and is a validated fall risk self-assessment tool (Rubenstein et al. J Safety Res; 2011: 42(6)493-499). Adapted with permission of the authors.

APPENDIX 5

1. Olen kaatunut viimeisen vuoden aikana
2. Käytän tai minulle on ehdotettu käyttää kävelykeppiä tai rullaattoria kävellessäni turvallisiseti
3. Joskus kävely tuntuu epävarmalta
4. Otan huonekaluista tukea kevelessäni kotona
5. Olen huolestunut että kaatuisin
6. Otan käsillä tukea tuolista nuostessani
7. Minulla on ongelma astuessa suojatien reunakivetyksen päälle
8. Minulla on usein kiire vessaan
9. Tunnen välillä että jalat ovat puutuneet
10. Kun otan lääkkeitä niin tunnen välillä päässä huimausta tai oloni on väsyneempi kun normaalisti
11. Otan lääkkeitä että saan nukuttua tai että mieliala olisi parempi
12. Tunnen välillä että olen alakuloinen tai masentunut

Suostumus osallistua projektiin, joka liittyy Alex Bondénin ja Luca Masierin fysioterapia opinnäytetyöhön.

Projektissa osallistujat jaetaan kahteen eri ryhmään. Molemmat ryhmät seuraavat omaa treeniohjelmaa. Ohjelmissa arvioidaan tasapaino vaikutuksen paranemista. Tasapainoa testataan treeniohjelaman alussa ja lopussa kolmella eri testillä. Treenejä tulee olemaan 8 – viikon aikana kerran viikossa. Treenit suoritetaan kesäkuu – lokakuu välisenä aikana.

Olen saanut tietoa tutkimuksen sisällöstä ja sen tavoitteista, kuinka koko projekti toteutetaan käytännössä ja aiheista, joita tutkimus kattaa. Minulle on annettu mahdollisuus kysyä lisätietoja tutkimuksesta.

ovat saaneet tietoa henkilötietojen käsittelystä tutkimuksessa. Minulle on luvattu, että henkilötietojani käsitellään huolellisesti ja tietoturvallisuusohjeiden mukaisesti, eikä niitä paljasteta ulkopuolisille. Ainoastaan opinnäytetyön tekijät käyttävät ja tallentavat tietoja.

Annan osallistujien luvan käyttää valokuvia ja videoita, joissa esiinnyn, tuottaa jotain opinnäyteprojektiin liittyvää materiaalia (esimerkki lyhyt video yhteenvetona projektista)

Olen tietoinen siitä, että osallistun projektiin vapaaehtoisesti sekä osallistumalla fyysiseen kuntoiluun tai harjoitteluun teen sen täysin omalla vastuullani. Minulla on oikeus keskeyttää projekti milloin haluan.

Sijainti ja päivämäärä

Suostun haastatteluun

____

Osallistujan nimi

Suostumuksen vastaanottaja

____

Tutkijan nimi