

Pavan Bandara, Priyanth Croos

Different kind of rehabilitation exercises to reduce  
the number of falls among senior citizens

A literature review

---

Helsinki Metropolia University of Applied Sciences

Bachelor of Healthcare

Physiotherapy

Bachelor's Thesis

Spring 2018

Authors Title	Dissanayake Mudiyansele Pavan Akalanka Bandara Agneshian Priyanth Croos
Number of Pages Date	Different kind of rehabilitation exercises to reduce the number of falls among senior citizens - A literature review 26 pages + 1 appendices
Degree	Bachelor of Health Care
Degree Programme	Physiotherapy
Specialisation option	Physiotherapy
Instructors	Sanna Garam, Senior Lecturer Anu Valtonen, Principal Lecturer
<p>Falls among elderly population is one of the most common problems in the world that leads to majority of elderly hospitalizations and deaths. Aging reduces muscle strength, balance and coordination. Reduced muscle strength, endurance and power will promote to a deduction of physical functions below the limit. Because of that, activities of daily living (ADL) may become more challenging and impossible.</p> <p>Aim of this literature review research was to determine which type of exercises (balance, coordination and strengthening) has been proven most successful to reduce the number of falls among seniors.</p> <p>Method used for this thesis was literature review which follows the main principles of systematic search. A systematic search was conducted in PubMed, EBSCOhost and Cochrane. 7 Randomized Controlled Trials (RCT) articles were selected for the thesis which fulfilled the inclusion criteria.</p> <p>According to the results, majority of elders shows falls and injuries related to falls. Results show that exercise sessions of strength training, balance training and coordination exercises create major difference concerning the reduction number of falls among elderly population. Also, practising the following exercises shows significant reduction in falls: jumping exercises, resistance training, progressive resistance training, postural control exercises, flexibility exercises, gait training, agility exercises, endurance training, functional floor exercises and backward chaining exercises. Moreover, exercises can increase functional capabilities, and correcting skills can minimize the number of falls in older population.</p>	
Keywords	falls, elderly, rehabilitation, exercises

## Contents

1	Introduction	1
2	Literature review	2
2.1	Risk factors of falls	2
2.2	Prevalence of falls	3
2.3	Prevention of falls	4
3	Aim and methods	6
3.1	Aim and study design	6
3.2	Search strategy	6
3.3	Inclusion and exclusion criteria	8
4	Results	9
5	Discussion	16
6	Acknowledgement	18
7	References	19
8	Appendices	27
	Appendix 1. JBI critical appraisal checklist for randomized controlled trials	

## 1. Introduction

Globally compared to others, age group of persons over 60 years is growing faster than any other age group. In 2006, the number of people over 60 years was estimated to be as 688 million worldwide, and projected to grow close to two billion by 2050 (WHO 2007). According to the statistics of Finland and WHO, senior citizens are categorized as a person who is above 65 years. Also, Euro stats show that European population growth is increasing every year. Comparing to other age groups senior citizen growth rate is higher than in other categories (Eurostat Statistics Explained, 2017).

Falls among elderly population is one of the common problems in the world that leads to majority of elderly hospitalizations and deaths (WHO, 2004). When a person gets older, one's body functions reduce with age. Aging reduces muscle strength, balance and coordination. After age 30 strength and endurance will get reduced (10% reduction per decade), along with that, muscle power also gets reduced (30% loss per decade), Reduced muscle strength, endurance and power will lead to a deduction of a physical functions below the limit. Because of that, activities of daily living may become more difficult and impossible (Yannis, 2012).

According to Yannis, risk factors that lead to falls among old population are "age, gender, drugs, medical condition, balance and gait problem, reduced muscle strength, impaired mobility and gait, psychological conditions, nutritional deficiencies, attenuated vision, and foot problems." Due to risk factors falls among senior citizens lead to series conditions. Over 30% of elders above 65 years of age fall every year and half of the falls are frequent. About one in ten falls leads to serious life-threatening conditions such as, subdural hematoma, spinal injuries, brain injuries and hip fractures (Yannis, 2012). Because of these injuries Activities of daily living (ADL) are reduced. Hip injury is very common consequence and most life-threatening condition in elderly population. According to WHO 40% of falls worldwide are associated with deaths (WHO, 2018).

Different balance exercises give cost-effective and efficient way to improve balance and confidence in seniors. Regular performance of balance exercises combine with postural control system exercises gives demanding of the vestibular systems, stimulating coordination, strengthening lower limbs, ankle movements and vestibular-ocular reflex training (Anna, et al., 2016).

This Bachelor's Thesis objective is to find out what kind of training interventions have been used to reduce the number of falls among senior citizens.

## 2. Literature review

### 2.1 Risk factors of falls

According to Yannis, risk factors for falls among elders are gender, age, drugs (benzodiazepines increased the night falling risk by 44%), medical conditions, mobility and issue with gait, psychological issues, cognitive problems, foot problems, vision problems (cataract, glaucoma) and nutritional deficiencies (vitamin D) can be major risk factors. Also, muscle weakness leads to falls, as well as imbalance in gait including the use of walking aids and assistive devices can increase the risk (Yannis, 2012). Furthermore, removal of dangerous places in environment can minimize the risk of falls. According to American Journal of Public Health an interdisciplinary and multifactorial prevention programme may reduce falls. Also, outdoor falls among seniors can minimize by modifying the environmental factors with promoting much more active life style to elderly persons (American Journal of Public Health, 2011).

According to Catharine, Cyrus and Avan, women over age 60 have more prone to fall than males at same age. Gender is one of the main risk factor for falls. Other than that socio demographic changes, life style and behavioral issues, medical conditions including severe pain and chronic conditions, physical and cognitive functions increase the risk of falls. Also, muscle weakness in upper and lower limb significantly increased the risk of falls. According to this publication urinary incontinence also categorized as a fall related risk factor (Catharine, Cyrus and Avan, 2016). Also, Sebastiana, et al., show low cognitive functions, self-reported medical conditions (stroke, urinary incontinence Parkinson's disease and foot disorders), number of medications, number of comorbid conditions, number of people living in a household, history of occupation (skilled or managerial/professional) categorized as risk factors that lead to falls (Sebastiana, et al., 2016).

## 2.2 Prevalence of falls

As an example, in Finland year 2006 senior citizens growth rate was 16.0% and the rate is increased to 20.5% within 4 years. It shows significant incensement of 4.5% within 4-year period of 2006 to 2010. According to CIA fact book estimated senior citizen rate in 2017 was 21.1% (male 506,342/ female 657,819) (CIA, 2018). Furthermore, this rate of senior citizen growth in Finland marked as the highest in whole Europe region.

Basically, increased life expectancy rate is major reason for this population growth. As an example, life expectancy rates in Finland are increasing every year. WHO statistics in Finland shows life expectancy rate is 81.1% in 2015 (WHO 2015). Due to increased life expectancy rate among senior citizens lead to some serious issues such as severe injuries or death. As reported by WHO global report on "Falls prevention in older age falls are prominent among the external causes of unintentional injury. 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" (WHO 2007).

For people aged 65 years and older, who live in United States of America, fall mortality rate is 36.8 (31.1 for women, 46.2 for men) per population of 100 000. Although in Canada mortality rate for people aged 65 is 9.4 per 10 000 population. For people aged 50 and older, who live in Finland, mortality rate for men is 55.4 and for women 43.1 per population of 100 000. Due to results of other countries Finland has one of the highest fall induced death rate (Rates can vary according to country and studied population) (WHO 2007).

According to Élise, et al., investigating accidental falls and weather data through different slippery conditions over three winter seasons in Finland shows falls among tourists is high in winter weather conditions (Élise, et al., 2016). Moreover, the circumstance of outdoor falls among elderly Finns are higher during the time of extreme cold than warmer periods. The role of weather conditions in winter was critical in injuries (Luukinen, Koski and Kivelä, 1996).

National falls prevention program in Finland main aims are to raise the awareness and educate about falls prevention, gain new action plans through government, implement

new legislations regarding safety and services for elderly people (National institute for health and welfare, 2016).

### 2.3 Prevention of falls

According to Pamela, most of the time older adults have gait and balance problems. Because of that they have difficulty in walking, sitting, standing and turning. To reduce those difficulties as a first step, need to educate elders some safety information about biomechanics. Physical therapy can improve their balance, coordination, flexibility, and reaction time. Additionally, tai chi classes, walking, weight lifting, standing on heels on toes or playing games can improve muscle strength and coordination. Some environmental factors contribute to falls like slippery floors and uneven surfaces. Providing safe guards, wearing hip pads and good supportive shoes and removing environmental hazards can be helpful to reducing number of falls (Pamela, 2014).

As reported by Seong and Duk, 2014 improving muscle strength and balance can reduce the number of falls among seniors. For that elastic-resistance exercise programs and balance exercises using interventions can improve muscle strength and balance among seniors very effectively. The elastic-resistance exercises consist of eight different types of exercises such as, heel raise, squats, hip flexion and extension, dorsiflexion and plantar flexion of ankle. For those exercises resistance was provided by Thera-Bands (Seong and Duk, 2014).

Tai chi is one of good choice for elderly people to improve balance and coordination. This includes slow, rhythmic movements focusing on trunk rotations, coordination, weight shifting between lower limbs and gradual narrowing of lower limb stance. In addition, low intensity balance and coordination training including tandem method is very effective to improve balance and coordination. The elders who cannot follow those exercises can go with hydrotherapy exercises by strengthening extremities, abdominal and back muscles (Yannis, 2012).

According to Charters, fall prevention exercises give high effectiveness in reducing falls. Falls prevention exercises were categorized as two main types. Preventing first time falls known as primary fall prevention exercises and preventing further fallings after first fall called secondary fall prevention exercises. Furthermore, most common evidence-based exercise programmes can prevent falls. For example, as tai chi, danc-

ing and gardening reduced the risk of primary falls among young and senior citizens with mild weakness of strength and balance. Also, Otago and Postural Stability programmes reduce secondary falls among senior citizens (Charters, 2013).

Recreational exercises including balance beam walking, foam croquet, badminton and foam hemisphere walking shows significant development in flexibility, muscle strength and balance during walking. Also, recreational exercises enhance motor functions and physical abilities while arousing motivation and interest for the exercises with an inexpensive way (Seong, Duk and Won, 2014).

Otago home exercise programme was specially designed to prevent falls by walking plan, lower extremity strengthening programmes and balance re-education programmes progressing in difficulty. The whole exercise programme takes about half an hour to complete. To get best results participants must follow the programme weekly three times and walk at least twice a week. And recommended follow ups need to continue every six months with an instructor [*Otago Exercise Programme to prevent falls in older adults*] (Anon., 2007).

According to Suk and David, aqua therapy exercises help to prevent falls. Continuing 12 weeks hydrotherapy exercise sessions develop the flexibility, muscle strength, power, balance and agility. Also, exercises reduce the weight and body fat mass (Suk and David, 2013).

Multi component exercise intervention programme including endurance, strength and balance training appears to be the perfect procedure to improving balance, strength, and gait. Also maintain functional capacity during aging can reduce the risk of falls. To maintain functional capacity in elders can follow exercises include endurance training by cycling, step-ups, staircase climbing and treadmill walking. To improve balance heel toe walking, one leg standing, modified tai chi, tandem training, multi directional weight lifts, stepping and line walking practice. And to increase functional capability resistance programme include the exercises to stimulate daily activities like walking and sit to standings. Multi component training includes gradual incensement of volume and repetition (Eduardo, et al., 2013).

Long term practice of tai chi exercises can minimize the frequency of falls and risk of falls by 55%. Practicing three times per week over six months of duration can reduce

the fear of falling number of falls and risk of fallings. Also, it enhances the functional mobility, physical performance and functional balance in physically inactive persons over age 70 (Fuzhong, et al., 2005). For seniors, reduced strength and balance are the main risk factors of falls. Hence, for the elderly, exercises to prevent falls include balance training exercises, coordination exercise and muscle strengthening exercises (Gschwind, 2013).

### **3. Aim and methods**

#### **3.1 Aim and study design**

Aim of this literature review research was to investigate which type of exercises (Balance, coordination and strengthening) have been proven most successful to reduce the number of falls among seniors.

Method used for this thesis was literature review which follows the main principles of systematic search.

#### **3.2 Search strategy**

Data collection method – Systematic search and literature review using randomized controlled trails (RCT).

A literature review was carried out publications published after 2000. Searches were conducted during December 2017 to March 2018 in the PubMed, EBSCOhost and Cochrane Library databases using following keywords: falls, fallings, fracture, hip fracture, injuries, death, risk factors, prevention, senior citizens, elders, elderly, seniors, old people, balance and coordination, exercises, muscle strengthening, rehabilitation, training physiotherapy, physical therapy and RCT.

To limit the errors and limit the searches publication language used as English and target population group considered as Senior citizens. Age of subjects included was over 60 years. Also, all the articles were RCT articles.

Study flowchart that was used in this thesis is presented in figure 1.

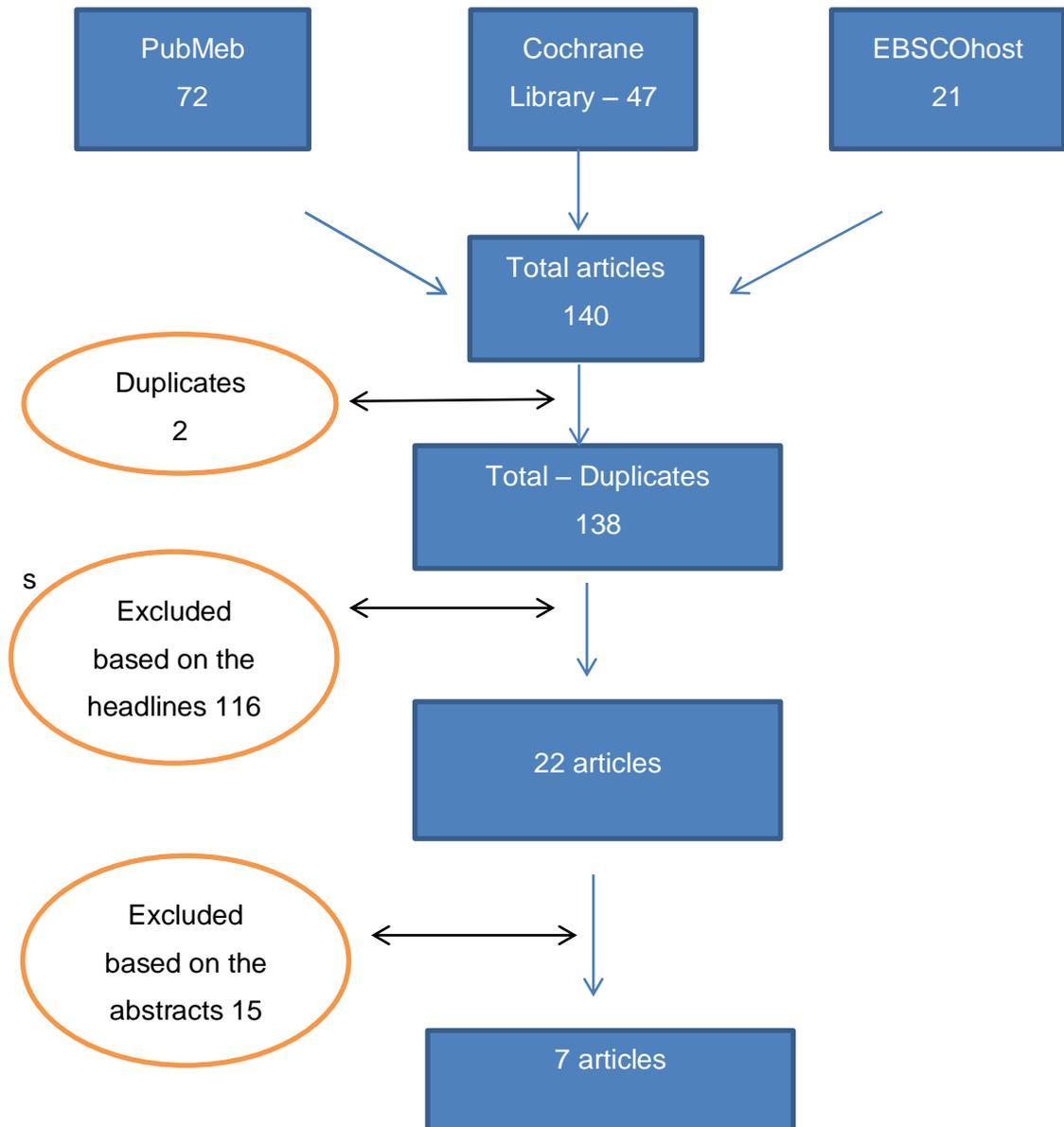


Figure1. Study flowchart of application process for systematic literature review studies

### 3.3 Inclusion and exclusion criteria

Inclusion and exclusion criteria that were used in this thesis are presented in table 1

Table 1. The inclusion and exclusion criteria used in thesis.

	Inclusion criteria	Exclusion criteria
Population	Age range 60 and above	Age range below 60
Publication date	Publications after year 2000	Articles published before year 2000
Publication language	Publications in English	Articles not published in English
Method	RCT method publications	Publications done with other than RCT methods
Contents	Articles related to muscle strength, balance and coordination	Articles not related to muscle strength, balance and coordination

#### Quality included studies

Critical appraisal is done by applying The Joanna Briggs Institute (JBI) critical appraisal checklist (The Joanna Briggs Institute, 2017, p.03.).

Joanna Briggs Institute (JBI) critical appraisal checklist presented in appendix 1.

#### 4. Results

According to inclusion and exclusion criteria seven research articles were selected for the review and all the articles are randomized controlled trials (RCT). Quality assessment was done by using The Joanna Briggs Institute (JBI) critical appraisal checklist. Results of the quality evaluation of the studies and more detailed information are presented in Table 2. To improve the quality of this thesis all the selected articles got at least seven yes answers from JBI critical appraisal checklist. Five selected articles were from PubMed, one article from EBSCOhost and one article from Cochrane Library databases.

According to Karinkanta, et al., 12 months' duration of intensive multi component exercise training shows decrease rate of injurious falls and fractures during 5-year post intervention period. Exercise training includes muscle strength, balance and jumping exercises. Also, combined resistance and balance-jumping training (COMB) can increase the physical functions and bone strength. The multi component exercises training reduced the rate of falls 62% to 51%. Also, it reduced the overall fracture risk by 74% (Karinkanta, et al., 2015).

According to Waterman, et al., intervention conducted six months of period and after that performed 6 months' follow up programme. The effects of home safety assessment and modifications with home safety exercise programme can prevent falls among older people with sight impairments. Also, strength and balance exercise plan prescribe individually and perform half an hour at least three times a week. Walking plan needs to be performed at least two times per week (Waterman, et al., 2016).

Use of multidisciplinary assessment and treatment of risk factors of falls can reduce the incidents of falls among seniors. Multidisciplinary assessment contains history of medical and drugs, physical examination, falls and mobility history. Potentially modifiable risk factors include postural hypotension, visual impairment, musculoskeletal conditions like osteoporosis and osteoarthritis, gait disorders (hemiplegic gait, diplegic gait, and neuropathic gait) and coordination problems (Parkinsonism), drug use, and environmental risks. Multifactorial treatments including withdrawal of drugs, reduction of home hazards, refer to responded healthcare worker and start balance and coordination and strength training exercises by a Physiotherapist (Peeters, et al., 2007).

According to Dawn, et al., home exercises programme started with 30 minutes session two times per week. Those exercises were advanced to more challenging balance training exercises in group therapy sessions. Exercise programme consisted of balance focused trainings personally accommodated and targeted muscle training for dynamic balance, flexibility, strength, functional capabilities, gait and endurance training to increase suitability or correcting the skills to prevent falls. The session also includes backward chaining and functional floor exercises. Also, home exercises focused on reducing asymmetry of lower limbs and increase the strength. Evidence show that individualized, progressive, strength and balance training exercises can minimize the risk falls among old people who had frequent falls up to 31% during the total trial period. Also, effective exercises can reduce falls by maintaining threshold levels of power and strength that are necessary to remain to be remaining independent. In addition, home exercises can minimize depression, fear, and associated avoidance of activities.

As reported by Kirsti, et al., two years follow up exercise program consisted of balance, strength, resistance training, agility, mobility training and adequate intake of vitamin D. It suggests exercises and Vitamin D needs to be essential part of their day to day life in senior population and it helps to prevent injurious falls. According to results former exercise intervention group shows lower rate of falls compared to other groups. Also taking Vitamin D without continuing exercises was combined with small number of falls without improving physical functions (Kirsti, et al., 2017).

Seniors who practiced elastic exercises over 6 month of period had higher performance in all functional fitness indicators than other controlled group. Indicators include lung capacity, muscle power, endurance, and flexibility of joints and activities of daily living. Also, study shows muscle strength is an important aspect in the balance adjustment and reported as major causes of falls of the elderly by aging. Moreover, resistance exercises using elastic bands (Thera bands) are very effective to increase muscle strength in elderly population (Kuei-Min, et al., 2015).

As reported by Chiung and Nancy, 2009 progressive resistance training effective in older adults by improving physical functions including strength and performance. Result show that sample population in progressive resistance training group shows less falls than controlled group. In exercise programme participants must exercise their muscles against some external force. Intensity of the force differs with the participants' capabil-

ity. Elastic bands, free weights and cuff weights and weight machines were used to provide resistance.

Out of 7 articles, 6 of articles described that muscle strength exercises reduce falls among older adult (Chiung and Nancy, 2009; Kirsti, et al., 2017; Karinkanta, et al., 2015; Kuei-Min, et al., 2015; Waterman, et al., 2016; Dawn, et al., 2005). and out of 7 articles, 4 of articles have described balance training reduce falls among older adults (Kirsti, et al., 2017; Karinkanta, et al., 2015; Waterman, et al., 2016; Dawn, et al., 2005). Out of 7 articles, 2 of articles have described coordination training can reduce the falls among elderly citizens (Karinkanta, et al., 2015; Dawn, et al., 2005).

Table 2. Conclusions made by the original authors.

<i>Authors, Year and place</i>	<i>Purpose of the study</i>	<i>Methods</i>	<i>Participants</i>	<i>Results and conclusion</i>	<i>Validation assessment (According to JBI)</i>
Chiung and Nancy, 2009  USA, Canada, Australia or New Zealand, various European countries	To investigate the effectiveness of Progressive Resistance Training (PRT) on elderly people and analyze the adverse effects	Systematic review RCT	Over 60 years old people 6700 participants	Progressive Strength Training is effective in older population by improving physical functions including strength and performance. Participants in the PRT group show less falls than control group	Yes=08 No=05 Unclear=0 N/A=0
Kirsti, et al., 2017  Finland	To assess combined effects of Vitamin D and Exercise on fall-induced injuries	RCT	409 home dwelling age range 70 to 80 years old women	Former exercise groups show less rates of falls analyze with referents 2 years after intervention. Vitamin D supplement with no exercise was associated with less injurious falls without changes in physical functioning	Yes=07 No=06 Unclear=0 N/A=0

Karinkanta, et al., 2015 Finland	To assess whether Combined resistance and balance-jumping exercise had long term effects in reducing falls and fractures among senior citizens	RCT	145 community dwelling participants  Female age range 70 to 78 years	12 Month exercise programme can reduce falls and fractures among older women	Yes=09 No=04 Unclear=0 N/A=0
Kuei-Min, et al., 2015 Southern Taiwan	To test the effectiveness of 6-month Wheelchair-bound senior Thera-Band exercises on the functional fitness of elders in nursing care centers	Cluster randomized trial RCT	114 participants completed the study out of 127, aged 65 and over  Participants must use wheelchairs, live at least 3 months in the facility; have intact cognition and dependency in activities of daily living (ADL).	Frequent training of exercises with elastic band significantly increased the functional fitness of the older adults in wheelchairs.  Muscle strength is important aspect in the balance adjustment and was also reported as a major cause of falls in old population.	Yes=07 No=06 Unclear=0 N/A=0
Waterman, et al., 2016	Purpose of this study is to optimize the design and investigation of home safe-	RCT	Population of 49, community dwelling aged 65 years and older and	Sample population recruited over a 9-month period, although self-reported physical activity	Yes=08 No=05 Unclear=0

North West England	ty and home exercise programmes to prevent falls among senior citizens with sight impairment		sight impaired	increased, instrumented monitoring showed a decrease in walking activity. Also, home exercises can reduce number of falls among old population.	N/A=0
Peeters, et al., 2007  Netherlands	Assess the capability and cost-effectiveness of a multidisciplinary assessment and treatment of multiple fall risk factors in independently living older persons with a high risk of falling.	RCT with an economic evaluation	Population of 100 old people age range 65 years and above.	According to study effective and implementation of multidisciplinary assessment followed by treatment of fall risk factors will minimize the frequency of falls.	Yes=08 No=05 Unclear=0 N/A=0
Dawn, et al., 2005	To study if tailored group exercise reduces injuries or falls in a high-risk group	RCT	Population of 81 frequent falls among older women aged 65 years and over	According to results 31% of falls reduction shows in exercise group compared to control group	Yes=08 No=05 Unclear=0

	of frequent fallers			in the period of the trail.  Evidence shows individualized, progressive, strength and balance training exercises can reduce the falls among old people who had frequent falls	N/A=0
--	---------------------	--	--	---	-------

## 5. Discussion

Research on falls among senior population is growing in number. In this literature review considerable numbers of studies were found where the effectiveness of different type of exercises to prevent falls was investigated. Purpose of this study was to identify the different type of exercises to decrease the risk of falling.

Furthermore, most of the previous studies (Chiung and Nancy, 2009; Kirsti, et al., 2017; Karinkanta, et al., 2015; Kuei-Min, et al., 2015; Waterman, et al., 2016; Dawn, et al., 2005) recommended strength training exercises, balance training exercises and coordination exercises creates major difference in reducing number of falls among elderly population.

In several fall prevention studies (Kuei-Min, et al., 2015; Dawn, et al., 2005; Karinkanta, et al., 2015; Chiung and Nancy, 2009) showed that other than balance, strength, coordination exercises and few other exercise methods also effective in deducting falls. As an examples jumping exercises, resistance training exercises, progressive resistance training, postural control exercises, flexibility exercises, gait training, agility exercises, exercises for endurance training, functional floor exercises, backward chaining exercises and the exercises that used to reduce asymmetrical in lower limbs. Practicing these exercises show significant reduction in falls.

In addition, increasing functional capabilities, and correcting skills can reduce the number of falls in older population. Exercise training can promote few other advantages as well, such as increase lung capacity, reduce fear and depression, and decrease associated avoidance of activities.

According to the studies that were used in this literature review, falls are more common in elderly people because of ageing factor; falls are more frequent in females than males. The main risk factors about falls are age, gender, drugs, physical problems, psychological problems, vision problems, and nutrition deficiency. Ageing factor reduces physical performance in elderly people; because of that senior population have poor muscle strength, low level of balance and coordination, as well as difficulty in walking. The interconnection between balance and coordination, muscle strength and falls in elderly population was very important. It depends on the type of exercise, duration; intensity and frequency affect the prevention of falls among elderly people.

The studies include results and reported findings on the association between the physical activity level and prevention of falls. To increase physical activity levels performs muscle strengthening exercises with elastic band exercises are more common in previous studies (Kuei-Min, et al., 2015). Those studies focus on lower limb muscle strength. Balance and coordination may have improved by the Thai chi and yoga movements, aquatic therapy exercises. Those exercises can increase muscle strength, balance and coordination. Some other studies mention that aerobic exercises help to improve ADL activity level in elderly people.

Seven randomized controlled trials were used in results. We used those articles to investigate which exercise method may be useful to prevent falls among elderly population. The studies showed promising results in exercises like muscle strength, balance and jumping exercises (Karinkanta, et al., 2015), strength and balance exercise (Waterman, et al., 2016), start balance and strength training exercises by a Physiotherapist (Peeters, et al., 2007). 30 minutes of home exercises and group exercise programme performing twice a week can be very useful to prevent falls among seniors. Those exercise sessions include dynamic balance, strength, flexibility, gait, functional capabilities, endurance training, resistance training, agility and mobility training (Dawn, et al., 2005), (Kirsti, et al., 2017), Performing elastic exercises over 6 months' time period can increase the lung capacity, muscle power, endurance, and flexibility of joints and activities of daily living.( Kuei-Min, et al., 2015). According to results positive outcome comes from different exercises. Also, proper exercise sessions and physical activities can be used to prevent falls among elderly people.

Strengths of this thesis were majority of the selected articles provides relevant results according to this Bachelor's Thesis aim and research question. Also selected articles show other than balance, coordination and strength training different methods of trainings and exercises can reduce number of falls among senior citizens. Major weakness was it is difficult to find quality RCT articles that relate to our research question. Because of that, only seven articles were selected. We recommend that responsible authorities could implement exercise programs and training programs to elderly people and healthcare professionals could also explain the risk factors and preventing ways of falls to their clients. Moreover, other researchers could start studies regarding this global issue and could try to find new ways to implement reduction of falls among elderly people.

## 6. Acknowledgement

We take this opportunity to express our profound gratitude and deep regards to our supervisors Sanna Garam (Senior Physiotherapy Lecturers from Metropolia University of Applied Sciences) and Anu Valtonen (Principal Lecturer from Metropolia University of Applied Sciences) for exemplary guidance, monitoring, insights and constant encouragement throughout the period of this Bachelor thesis. It's a great honor to work under your supervision.

## 7. References

Aaron, M. W., Michael, G. L., 2011. Increased Fall-Related Mortality Rates in New Mexico, 1999–2005. *Pubmed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3185322/>> [Accessed 28 January 2018].

ACC Prevention care recovery, 2007. *Otago Exercise Programme to prevent falls in older adults*. [pdf] ACC Prevention care recovery. Available at: <<https://www.acc.co.nz/assets/injury-prevention/acc1162-otago-exercise-manual.pdf>> [Accessed 16 March 2018].

Age UK, 2013. *Falls Prevention Exercise – following the evidence*. [pdf] Age UK. Available at: <<http://agile.csp.org.uk/documents/falls-prevention-exercise-%E2%80%93-following-evidence>> [Accessed 07 March 2018].

Aimee, L., Kuo, W. L., Peter, K., 2013. Preventing Falls in the Geriatric Population. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3854807/>> [Accessed 27 January 2018].

American Journal of Public Health, 2011. Outdoor Falls Among Middle-Aged and Older Adults: A Neglected Public Health Problem. [online] Available at: <<http://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2005.083055>> [Accessed 03 March 2018].

Anna, H., Eva-Maj, M., Josefine, T., Per-Anders, F., Måns, M., 2016. Improved Balance Confidence and Stability for Elderly After 6 Weeks of a Multimodal Self-Administered Balance-Enhancing Exercise Program. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5119910/>> [Accessed 05 March 2018].

Annals of Internal Medicine, 2002. Fall and Injury Prevention in Older People Living in Residential Care Facilities. *A Cluster Randomized Trial*. ARNNetwork, Pamela, M.F., 2007. *Preventing Falls in Older Adults*. [pdf] ARNNetwork available at: <[https://www.researchgate.net/profile/Lisa\\_Barnett4/publication/43524121\\_Preventing\\_falls\\_in\\_older\\_adults/links/00b7d51f06ddd04ead000000/Preventing-falls-in-older-adults.pdf](https://www.researchgate.net/profile/Lisa_Barnett4/publication/43524121_Preventing_falls_in_older_adults/links/00b7d51f06ddd04ead000000/Preventing-falls-in-older-adults.pdf)> [Accessed 08 March 2018].

Barnett, A., Smith, B., Lord, S.R., Williams, M., Baumand, A., 2003. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomized controlled trial, *PubMed*. [online] Available at: <<https://www.ncbi.nlm.nih.gov/pubmed/12851185>> [Accessed 2 February 2018].

Barnett, A., Smith, B., Lord, S.R., Williams, M., Baumand, A., 2003, Community-based group exercise improves balance and reduces falls in at-risk older people: a randomized controlled trial. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pubmed/12851185>> [Accessed 29 January 2018].

Catharine, R. G., Cyrus, C., Avan, A, S., 2016, Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. *British Geriatrics Society*, [Online] Available at :< <https://academic.oup.com/ageing/article/45/6/789/2499223>> [Accessed 03 March 2018].

Central Intelligence Agency, 2018. *The World Fact book, Europe, Finland*. [online] (22 February 2018) Available at: < <https://www.cia.gov/library/publications/the-world-factbook/geos/fi.html>> [Accessed 05 February 2018].

Chiung, L., Nancy, K., 2009. Progressive resistance strength training for improving physical function in older adults. *Cochranelibrary*, [online] Available at :< <http://cochranelibrary-wiley.com/doi/10.1002/14651858.CD002759.pub2/full>> [Accessed 15 March 2018].

David, A., Sleet Daphne, B., Moffett, J.S., 2008. CDC's research portfolio in older adult fall prevention: A review of progress, 1985-2005, and future research directions. *PubMed*, [Online] Available at: <https://www.sciencedirect.com/science/article/pii/S0022437508000741> [Accessed 27 January 2018].

Dawn, S., Susie, D., Malcolm, C., Olga, R., 2005. Tailored group exercise (Falls Management Exercise — FaME) reduces falls in community-dwelling older frequent fallers (an RCT). *PubMed*, [online] Available at :< <https://academic.oup.com/ageing/article/34/6/636/40192> > [Accessed 18 March 2018].

Debra, J. R., 2012. *The Role of Physical Activity in the Prevention of Falls in Older Age*. [pdf] California State University, Fullerton, CA. Available at :< <http://www.who.int/ageing/projects/6.Role%20of%20physical%20activities%20in%20falls%20prevention.pdf>> [Accessed 2 February 2018].

Department of Public Health Science and General Practice, University of Oulu, 1995. *The relationship between outdoor temperature and the frequency of falls among the elderly in Finland*. [pdf] Department of Public Health Science and General Practice, University of Oulu. Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1060216/pdf/jepicomh00181-0114.pdf>> [Accessed 27 January 2018].

Edgren, J., Salpakoski, A., Sihvonen, S.E., Portegijs, E., Kallinen, M., Arkela, M., Jäntti, P., Vanhatalo, J., Pekkonen, M., Rantanen, T., Heinonen, A., Sipilä, S., 2015. Effects of a home-based physical rehabilitation program on physical disability after hip fracture: a randomized controlled trial. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pubmed/25687927>> [Accessed 29 January 2018].

Eduardo, L. C., Leocadio, R.M., Alan, S., Mikel, I., 2013. Effects of Different Exercise Interventions on Risk of Falls, Gait Ability, and Balance in Physically Frail Older Adults: A Systematic Review. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3634155/>> [Accessed 17 March 2018].

Élise, L., Sinikka, R., Antti, H., Pentti, N., Marjo, H., Arja, R., 2016. Role of Winter Weather Conditions and Slipperiness on Tourists' Accidents in Finland. *PubMed*, [Online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4997508/>> [Accessed 03 March 2018].

Élise, L., Sinikka, R., Antti, H.P. N., Marjo, H., Arja, R., 2016. Role of Winter Weather Conditions and Slipperiness on Tourists' Accidents in Finland. *PubMed*, [Online] Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4997508/> [Accessed 27 January 2018].

Erika, Y. I., Lidiane, G. R., Elisa, S. C., Adriana, C. L., 2014. Effectiveness of muscle strengthening and description of protocols for preventing falls in the elderly. *Brazilian Journal of Physical Therapy*, [Online] Available at :< [http://www.scielo.br/scielo.php?script=sci\\_arttext&pid=S1413-35552014000200111](http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1413-35552014000200111)> [Accessed 2 February 2018].

Eurostat statistics explained, 2017. *Mortality and life expectancy statistics* [Online] (19th September 2017) Available at :< [http://ec.europa.eu/eurostat/statisticsexplained/index.php/Mortality\\_and\\_life\\_expectancy\\_statistics](http://ec.europa.eu/eurostat/statisticsexplained/index.php/Mortality_and_life_expectancy_statistics)> [Accessed 20 November 2017].

Fuzhong, L., Peter, H., John F. K., Edward, M., Nigel, C., Elizabeth, E., Nicole, L. W., 2005. Tai Chi and Fall Reductions in Older Adults: A Randomized Controlled Trial. *Oxford University Press*, [Online] Available at: < <https://academic.oup.com/biomedgerontology/article/60/2/187/563288>> [Accessed 20 March 2018].

Hartholt, K.A., van der, V. N., Looman, C.W, Lieshout, E.M., Panneman, M.J., Beeck, E.F., Patka, P., van der Cammen, T.J., 2010. Trends in fall-related hospital admissions in older persons in the Netherlands. *PubMed*, [Online] Available at: <https://www.ncbi.nlm.nih.gov/pubmed/20498419> [Accessed 28 January 2018].

Harvard Health Publishing, Harvard Medical School, 2013. Balance training seems to prevent falls, *injuries in senior* [online] Available at: <<https://www.health.harvard.edu/blog/balance-training-seems-to-prevent-falls-injuries-in-seniors-201310316825>> [Accessed 2 February 2018].

In-Hee, Lee., Sang-young, P., 2013. Balance Improvement by Strength Training for the Elderly. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3885846/>> [Accessed 2 February 2018].

Joanna Briggs Institute, 2017. *Critical appraisal tools*. [online] Available at: <<http://joannabriggs.org/research/critical-appraisal-tools.html>> [Accessed 05 March 2018].

Jung-Hyun, C., Nyeon-Jun, K., 2015. The effects of balance training and ankle training on the gait of elderly people who have fallen. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4305545/>> [Accessed 2 February 2018].

Karinkanta, S., Kannus, P., Uusi, R., Heinonen, A., Sievänen, H., 2015. Combined resistance and balance-jumping exercise reduces older women's injurious falls and fractures: 5-year follow-up study. *PubMed*, [online] Available at: <<https://academic.oup.com/ageing/article/44/5/784/51854>> [Accessed 3 March 2018].

Karinkanta, S., Piirtola, M., Sievänen, H., Uusi-Rasi, K., Kannus, P., 2010. Physical therapy approaches to reduce fall and fracture risk among older adults. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pubmed/20517287>> [Accessed 29 January 2018].

Kuei, M. C., Chun, H. L., Ya-Hui, C., Hsin-Ting, H., Yin-Yi, C., 2015. An elastic band exercise program for older adults using wheelchairs in Taiwan nursing homes: A cluster randomized trial. *Ebscohost*, [online] Available at: <<http://web.a.ebscohost.com.ezproxy.metropolia.fi/ehost/detail/detail?vid=3&sid=a29b7bc6-297a-4e0d-9165-fc2b41d473ff%40sessionmgr4008&bdata=JnNpdGU9ZWWhvc3QtbGl2ZQ%3d%3d#AN=103860038&db=ccm>> [Accessed 5 March 2018].

Luukinen, H., Koski, K., Kivelä, S.L., 1996. The relationship between outdoor temperature and the frequency of falls among the elderly in Finland. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4997508/>> [Accessed 2 February 2018].> [Accessed 17 February 2018].

Luukinen, H., Koski, K., Kivelä, S.L., 1996. The relationship between outdoor temperature and the frequency of falls among the elderly in Finland. *PubMed*, [Online]

Available at: < <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1060216/>> [Accessed 30 January 2018].

National institute for health and welfare, 2016. *National falls prevention program in Finland*. [online] Available at:< <https://thl.fi/fi/web/injury-prevention/accidental-injuries/older-people/national-falls-prevention-program-in-finland>>>[Accessed 03 March 2018].

Negreiros, C., Perracini, M.R., Soares, A.T., de Cristo, S. F., Sera, C.T., Tiedemann, A., Sherrington, C., Filho, W.J., Paschoal, S.M., 2013. Effectiveness of a multifactorial falls prevention program in community-dwelling older people when compared to usual care: study protocol for a randomised controlled trial (Prevquedas Brazil). *PubMed*, [online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3606610/>> [Accessed 22 March 2018].

Niina Korhonen, University of Tampere, 2014. *Fall-Induced Injuries and Deaths Among Older Finns Between 1970 and 2012*. [Pdf]. University of Tampere. Available at: < <https://tampub.uta.fi/bitstream/handle/10024/96374/978-951-44-9638-7.pdf?sequence=1> > [Accessed 27 January 2018].

Peeters, G.M., de Vries, O.J., Elders, P.J., Pluijm, S.M., Bouter, L.M., Lips, P., 2007. Prevention of fall incidents in patients with a high risk of falling: design of a randomised controlled trial with an economic evaluation of the effect of multidisciplinary transmurial care. *PubMed*, [online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1933430/>> [Accessed 7 February 2018].

Portegijs, E., Edgren, J., Salpakoski, A., Kallinen, M., Rantanen, T., Alen, M., Kiviranta, I., Sihvonen, S., Sipilä, S., 2012. Balance confidence was associated with mobility and balance performance in older people with fall-related hip fracture: a cross-sectional study. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pubmed/22698990>> [Accessed 30 January 2018].

Portegijs, E., Kallinen, M., Rantanen, T., Heinonen, A., Sihvonen, S., Alen, M., Kiviranta, I., Sipilä, S., 2008. Effects of resistance training on lower-extremity impairments in older people with hip fracture. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pubmed/18760151>> [Accessed 30 January 2018].

Salminen, M., Vahlberg, T., Sihvonen, S., Piirtola, M., Isoaho, R., Aarnio, P., Kivelä, S.L., 2008. Effects of risk-based multifactorial fall prevention program on maximal isometric muscle strength in community-dwelling aged: a randomized controlled trial. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pubmed/19039292>> [Accessed 29 January 2018].

Sculthorpe, N.F., Herbert, P., Grace, F., 2017. One session of high-intensity interval training (HIIT) every 5 days, improves muscle power but not static balance in life-

long sedentary ageing men: A randomized controlled trial. *PubMed*, [online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5313002/>> [Accessed 10 March 2018].

Sebastiana, Z. K., Monica, F., George, H. S., Motasim, B., 2016. Risk factors for falls in older adults in a South African Urban Community. *BMC Geriatrics*, [Online] Available at :< <https://bmcgeriatr.biomedcentral.com/articles/10.1186/s12877-016-0212-7>> [Accessed 15 March 2018].

Seong, C., Duk,H.A., 2014. Effects of a Fall Prevention Exercise Program on Muscle Strength and Balance of the Old-old Elderly. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4242952/>> [Accessed 27 January 2018].

Seong,C., Duk-hyun, A., Won-gyu Y., 2014. Effects of Recreational Exercises on the Strength, Flexibility, and Balance of Old-old Elderly Individuals. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4210403/>> [Accessed 29 December 2017].

Seong,C., Duk,H. A., 2014. Effects of a Fall Prevention Exercise Program on Muscle Strength and Balance of the Old-old Elderly. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4242952/>> [Accessed 29 January 2018].

Siracuse, J.J., Odell, D.D., Gondek, S.P., Odom, S.R., Kasper, E.M., Hauser, C.J., Moorman, D.W., 2012. Health care and socioeconomic impact of falls in the elderly. *PubMed*, [Online] Available at :< <https://www.ncbi.nlm.nih.gov/pubmed/22257741>> [Accessed 27 January 2018].

Suk, B. K., David, M. O., 2013. Effects of Aqua Aerobic Therapy Exercise for Older Adults on Muscular Strength, Agility and Balance to Prevent Falling during Gait. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3820233/>> [Accessed 16 March 2018].

United Nations, 2015. *World Population Ageing 2015*. [pdf] United Nations. Available at: [http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2015\\_Report.pdf](http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2015_Report.pdf) [Accessed 20 November 2017].

Uusi,R. K., Patil, R., Karinkanta, S., Kannus, P., Tokola, K., Lamberg-Allardt ,C., Sievänen, H.,2015. Exercise and vitamin D in fall prevention among older women: a randomized clinical trial. *PubMed*, [Online] Available at: <<https://www.ncbi.nlm.nih.gov/pubmed/25799402>> [Accessed 22 December 2017].

Uusi, R., Patil, R., Karinkanta, S., Kannus, P., Tokola, K., Lamberg, C., Sievänen, H., 2017. A 2-Year Follow-Up After a 2-Year RCT with Vitamin D and Exercise: Effects on Falls, Injurious Falls and Physical Functioning Among Older Women. *PubMed*, [online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5861967/>> [Accessed 17 March 2018].

Victoria, G., Louise, B., 2012. *Guidelines for the Physiotherapy management of older people at risk of falling*. [pdf] The chartered Society of Physiotherapy. Available at :< [www.csp.org.uk/sites/files/csp/secure/agile\\_falls\\_guidelines\\_update\\_2012\\_1.pdf](http://www.csp.org.uk/sites/files/csp/secure/agile_falls_guidelines_update_2012_1.pdf)> [Accessed 2 February 2018].

Waterman, H., Ballinger, C., Brundle, C., Chastin, S., Gage, H., Harper, R., 2016. A feasibility study to prevent falls in older people who are sight impaired: the VIP2UK randomised controlled trial. *PubMed*, [online] Available at :< <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037880/>> [Accessed 13 March 2018].

Wei, L., Chao, Y., Jau, Y.T., SenYang, R., 2014. Balance control in elderly people with osteoporosis. *Journal of the Formosan Medical Association*, [online] Available at: <[https://ac.els-cdn.com/S0929664614000692/1-s2.0-S0929664614000692-main.pdf?\\_tid=216d0fc2-4ba1-4acc-bba6-cdbe8e3d7ede&acdnat=1520533707\\_b6249345b22e0f6f3fa33b80743d568b](https://ac.els-cdn.com/S0929664614000692/1-s2.0-S0929664614000692-main.pdf?_tid=216d0fc2-4ba1-4acc-bba6-cdbe8e3d7ede&acdnat=1520533707_b6249345b22e0f6f3fa33b80743d568b)> [Accessed 2 February 2018].

WHO, 2004. *What are the main risk factors for falls amongst older people and what are the most effective interventions to prevent these falls?* [pdf] WHO. Available at: < [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0018/74700/E82552.pdf](http://www.euro.who.int/__data/assets/pdf_file/0018/74700/E82552.pdf)> [Accessed 08 March 2018]

World Health Organization, 2007. *WHO Global Report on Falls Prevention in Older Age*. [pdf] World Health Organization. Available at :< [http://www.who.int/ageing/publications/Falls\\_prevention7March.pdf](http://www.who.int/ageing/publications/Falls_prevention7March.pdf)> [Accessed 20 November 2017].

World Health Organization, 2018. *Falls*. [Online] Available at: < <http://www.who.int/mediacentre/factsheets/fs344/en/>> [Accessed 27 January 2018].

Yannis, D., 2012. Analyzing the problem of falls among older people. *PubMed*, [Online] Available at: < <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3468115/>> [Accessed 03 March 2018].

Yves, J G., Reto, W. K., Andre, L., Thomas, M., Barbara, P., Urs, G., 2013. A best practice falls prevention exercise program to improve balance, strength / power, and psychosocial health in older adults: study protocol for a randomized controlled

trial. *PubMed*, [Online] Available at :<  
<https://bmcgeriatr.biomedcentral.com/articles/10.1186/1471-2318-13-105>> [Ac-  
cessed 29 January 2018].

## 8. Appendices

Joanna Briggs Institute (JBI) critical appraisal checklist for randomized controlled trials presented in appendix 1.

### Appendix 1

<b>JBI Critical Appraisal Checklist for Randomized Controlled Trials</b>				
Reviewer	-----			
	Date	-----		
Author	-----	Year	-----	Record Number
	-----	-----	-----	-----
	Yes	No	Unclear	NA
1. Was true randomization used for assignment of participants to treatment groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Was allocation to treatment groups concealed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Were treatment groups similar at the baseline?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Were participants blind to treatment assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Were those delivering treatment blind to treatment assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Were outcomes assessors blind to treatment assignment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Were treatment groups treated identically other than the intervention of interest?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Were participants analyzed in the groups to which they were randomized?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Were outcomes measured in the same way for treatment groups?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. Were outcomes measured in a reliable way?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. Was appropriate statistical analysis used?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Overall appraisal:	Include	<input type="checkbox"/>	Exclude	<input type="checkbox"/>
	Seek further info	<input type="checkbox"/>		

(The Joanna Briggs Institute, 2017, p.03.)