Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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The effects of strength- and balance training on fall prevention amongst older adults

Bachelor's thesis in Human Movement Science
Supervisor: Mireille van Beekvelt
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A***bstract***

Background: Loss of muscle mass, impaired mobility and poor balance is some of the strongest predictors for falls in older adults. We hypothesize that different types of balance and strength training would affect the fall rate amongst older adults, due to the common knowledge of how important several different types of training for this generation is.
Method: 8 studies found trough PubMed were included. Participants at the age above 60. Different studies that included some sort of balance- or strength assessments/exercises or records of falls rates.
Results: Although several of the 8 studies showed great improvements on the physical factors, only 2 studies had a statistically significant decrease in fall rates.
Conclusion: Although only a few studies have significant change in fall rate, all studies show improved fall-related physical performance. Therefore, we cannot conclude with there being positive effects of balance- and strength training on fall prevention. Results are based on a limited number of studies, and further research is needed to establish a clear connection between balance- and strength training and fall prevention.

Abstrakt

Bakgrunn: Tap av muskelmasse, nedsatt bevegelighet og dårlig balanse er sterke prediktorer for fall blant eldre. Hypotesen ble formulert ut ifra at ulike typer balanse- og styrketrening vill påvirke fallraten hos eldre, basert på den allmenne kunnskapen om hvor viktig ulike typer trening er for denne aldersgruppen.
Metode: Vi gjennomførte et systematisk søk på PubMed og fant 8 relevante studier. Deltakerne i disse studiene var over 60 år gamle. Studiene inkluderte vurderinger/ øvelser som er rettet mot balanse eller styrke, samt registrering av fallrate.
Resultater: Selv om de fleste av de 8 studiene viste betydelig forbedring i fysiske faktorer knyttet til fall, rapporterte bare to av studiene en statistisk signifikant reduksjon i fallrate.
Konklusjon: Selv om flere studier viser forbedret fysisk ytelse relatert til fall, kan vi ikke konkludere med at balanse- og styrketrening har positive effekter på forebygging av fall. Resultatene er basert på et begrenset antall studier, og videre forskning i dette feltet er nødvending for å etablerer en klarere sammenheng mellom trening og forebygging av fall.

1. Introduction

World health organization (WHO) states that worlds population over 60 years will nearly double between 2015 to 2050, increasing from 12% to 22% (*www.who.int*). This is mainly due to the increase in life expectancy and reduction in worldwide birth rates. Advancements in medicine and science is the reason of the increase of life expectancy. Medicines and treatments that cure diseases which affect the older population the most are also important. This significant increase in older adults requires adaptation across all sectors of the community. This change affects health and social care, transportation, houses, and construction plans. The gradually increase of the older population can cause challenges amongst already crowded nursing homes all over the globe. This is due to the decrease of muscle strength, cognitive function and the ability to perform daily activities at home.

Aging is an inevitable and complex process that affects different aspects of the human life, including physical, physiological and social aspects. As humans advance in age, we face unique challenges related to maintaining our overall health and quality of life. Aging is also often associated with a decline in muscle mass, bone density and impaired balance. These age-related changes can increase the probability of falls and injuries, which further can have severe consequences on their health and independence. The most crucial aspect of aging is maintaining the physical function, particularly strength and balance (National Institute on Aging, 2022a). Adults above 60 years of age suffer the greater number of fatal falls. A fall can cause a serious injury such as breaking a bone or head trauma. Though not fatal, 37, 3 million falls require medical attention each year (World Health Organization, 2021)

A lot of studies show that physical activity and exercise have a great health benefit in all age groups. WHO recommends older adults above 65 years old to perform at least 150-300 minutes of aerobic physical activity (moderate intensity) per week. As a part of their exercise program, they should also include muscle strengthening activities that involve the big muscle groups three or more days a week. They should also include multicomponent physical activity that emphasizes on functional balance in these sessions (World Health Organization, 2022b).

Balance training is a generic term used to describe stability during various tasks. There are several different types of balance training. We decided to focus and include the studies who

had exercises that focus on balance in the lower extremity and/or abdominal stability. Studies with different types of balance test results (e.g. Berg Balance Scale) were also included.

Strength and resistance training is a form of exercise that requires skeletal muscles to exert force against some form of resistance. The type of resistance can vary between movable objects, cables, rubber bands or weights. Resistance exercise is a combination between dynamic and static muscle contraction (*Resistance Training - MeSH - NCBI*, u.å.). ". In older adults the most important muscle groups are in the lower extremities and the core muscles in the upper abdominal (National Institute on Aging, 2022b). When looking at different studies, we defined strength and resistance training as different movements that challenge older adults and target big and relevant muscle groups. The exercises can vary in degree of difficulty and execution.

Accidental falls are caused by slipping, tripping, loss of balance, lower body weakness or loss in concentration. The generic term "fall prevention" is used to describe several different measures used to reduce the risk of falling. These measures can vary from using indoor shoes to prevent slipping, to training the muscles of the lower extremities (National Institute on Aging, 2022c). In this study the focus is not the environmental factors, but exercises we think strengthens fall prevention. Mainly strength (resistance) and balance training. We hypothesize that strength- and balance training will improve fall prevention and thus reduce fall rates. Therefore, the research question of this article is to evaluate the effects of strength- and balance training on fall prevention amongst older adults.

2. Methods

The literature search was done in the PubMed database. The search included the keywords: "aging", AND "balance", AND "strength OR resistance", AND "training", AND "fall prevention". Only articles that were CTs or RCTs, conducted on humans and written in English were included. The search resulted in a total of 22 articles. Inclusion criteria were that articles must include some type of balance and/or strength exercise, and have some type of result, either fall statistics, strength- or balance test results. The study population had to be at least 60 years old. When the title and abstract indicated a potential inclusion, the full article

was reviewed for further consideration. Some articles consisted of only a description of the study protocols (n=2), and these were excluded. Several articles (N=6) included exercises forms who were beyond the scope of this study (e.g., virtual reality training, social dancing etc.). The rest of the excluded articles involved either a specific disease (e.g., Parkinson) or training combined with other factors (e.g., supplements). In total the search resulted in eight relevant articles who were included in this article.

3. Results

The eight studies included in this assignment have looked at different types of balance and strength- or resistance training. Studies included older people above 60 years. One study included Thai chi as a type of balance training, and two have implemented LiFE program into daily activities. Some of the studies have outcomes and data connected to fall prevention, the rest have different outcomes we consider as indirect factors that affect falls.

Article 1: Mora Pinzon et al. (2019) investigated the "Pisando Fuerte" program in 24 self-identified Hispanic or Latinos older people with a mean age of 70.5 years. All participants were placed in an intervention group (IG). The training period consisted of 8 sessions distributed to once per week. One session lasted 2.5 hours and was a combination of education and training. Education consisted of lessons about fall prevention and further instructions. The training consisted of strength and balance training. Participants completed a survey at baseline that included demographics, records of falls the last six months and the Fall Behavior Scale (FaB). The FaB scales is a tool that assesses the presence of protective behavior, ranking from 0 (not at all) to 4 (very much). Functional mobility was assessed using "Timed Up and Go" (TUG). Using a pre-post design, they compared the fall statistics from the last six months to the six months prior to the study. Participants had no decrease in the number of falls per person. TUG results in time required to complete the task were also non-significant. The FaB scale had a significant improvement from 2.69 at baseline to 3,16 at six months post intervention. Indicating that balance improved and need for protective behavior decreased.

Article 2: Zhuang et al. (2014) looked at the effectiveness of a combined exercise intervention on physical fitness factors related to falls in community-dwelling older adults. A total of 56 participants met the criteria and completed the baseline measurements. They were randomly divided into IG (n=28) and CG (n=28). Mean age of the participants was around 64 years old. The IG completed a 12-week exercise program. They received 60-minute exercise classes 3 times a week. Each session included 15 minutes of muscle-training, 15 minutes of Tai Chi and ending with 10 minutes flexibility/stretching. The participants in the CG were asked to maintain their usual form of physical activity. Measures were conducted at baseline and after 12 weeks of randomization. All participants were tested in the 30-second chair stand test (30-CS), TUG, functional reach test (FRT) and the star excursion balance test (SEBTs).

Zhuang et al. (2014) stated that FRT is measured due to it being a strong predictor for fall risk. Results after 12-weeks showed a significant improvement in the 30-CS and in the TUG test. There was no significant interaction for the FRT. SEBT test had significant improvements in all directions except the medial direction of the right limb stance. In the CG, there was a decreasing trend in physical performance after 12-weeks. An improvement was found amongst IG in Isokinetic strength. However, the effect was not significant for knee flexor strength and ankle extensor strength. The study claims the results showed that the program improved fall-related physical performance and gait parameters, indicating a reduced risk of falls, even though no records of falls were created or mentioned.

Article 3: Jensen et al. (2004) studied the effects of fall prevention program in frail older people living in residential care facilities. 187 residents were included in total. After baseline assessments, they were randomly selected into IG (n=89) and control group (CG) (n=98). The mean age of the two groups were 84 years old. Participants were assessed in “The Functional Ambulation Categories” (FAC) scale, gait speed, “The Berg Balance scale” and step height. FAC scale details the amount of human support needed in an independent transfer. Need of support from more than one person scores 0, and walking independently on uneven ground, stairs and slopes scores 5 on the scale. The Berg balance scale examines the ability to maintain a position (sitting or standing) in 14 items. Rating of the scale consider safety, time and distance. The tasks vary in level and difficulty.

Intervention program lasted 11 weeks and short-term effects were measured after the intervention. Long-term effects were tested and assessed after 9 months. The study physiotherapist kept an exercise record on the participants. 66 participants started to

participate in the exercise. 85% of them exercised 2-3 times a week, 53% had 1-3 hours exercise per week, while 6% had more than 3 hours per week. IG did balance exercises, resistance training on the lower extremities, gait training and safe movement behavior training. CG received usual care. Reports and record of falls were collected for both groups during the intervention period and the follow-up period.

Short term effects after 11 weeks were an increase in step height in IG. Balance measured by "Berg balance scale" showed an increase in the IG, however this was not statistically significant. FAC was maintained in the IG but decreased in CG. Maximum gate speed did not change in IG, but drastically decreased in CG. Both results were statistically significant. *Long term effects after 9 months* were an improvement in FAC in IG (70% at baseline compared to 75%). The CG had a decrease in FAC (64% at baseline compared with 45% at 9 months). No statistically significant result when it comes to fall rate.

Article 4: Ohtake et al. (2013) looked at how exercise could play a role in preventing the need of long-term care amongst older adults. There were 196 participants, all with a mean age of 83.6 years. After the physical assessments, included TUG, FRT, balance assessments and Fall prevention self-efficacy scale (FPSE), they were placed randomly in IG (n=110) or CG (n=86). The intervention group participated in an 8-week exercise period. They also received instructions to perform the exercises at home. The total amount was based on their participation to the program, and a record sheet for the home exercises. They were requested to exercise the program once a week, and two- three times a week at home. The training consisted of six types of stretching, six types of muscle training, two types of balance training and toe stretching. The CG was offered the usual program for prevention of long-term care. This included health education, recreational activities, and hobby activities.

On average the home exercise was performed 3.8 days a week. The IG had a significant increase in FRT (27.1cm vs 22.9cm). FPSE scale improved amongst the IG. No significant changes in the other physical aspects. During the intervention period, 7,6% of the IG and 12,1% of the CG reported a history of fall. The difference was not statistically significant. However, 76.1% of IG responded that the fall-prevention program had an effect.

Article 5: Liu-Ambrose et al. (2019) investigated the effects of a home-based exercise program on falls among community-dwelling high risk older adults. Participants were recruited from the Falls Prevention Clinic. 345 participants were randomized into a CG (n=172) and IG (n=173). The intervention period was 12 months. Assessments were made at baseline, 6 months and after 12 months after randomization. Record of falls over 12 months were self-reported and documented in a calendar. Assessments relevant in this study, was only the "Time up and Go" test. The IG performed the Otago Exercise program, a home-based strength and balance program delivered by a physical therapist. It includes 5 strength- and 11 balance exercises. Participants were asked to perform the program at least 3 times a week, but also walk 30 minutes at least twice a week. CG received usual care in the same period. During a mean follow-up time of 338 days, 236 falls in the IG and 366 falls in CG were recorded. Difference in physical assessments (including TUG) at 12 months vs. baseline was not statistically significant. Thus, it is possible to observe reduction in falls without a significant improvement in physical performance.

Article 6: Nerz et al. (2022) investigated group-based and individually Lifestyle-integrated functional exercise (LiFE) as a fall prevention program. 252 older adults with a mean age of 78.6 years participated. They were randomized and then divided into group-based LiFE activities (gLiFE) and individually LiFE activities. All participants were assessed at baseline, after 6 and 12 months. Assessments of balance was based on the results on the 8-level balance scale, 30 second chair stand (30-CS) for strength and Physical activity was measured with accelerometers. Rather than a prescribed set of exercises performed several times a week, the LiFE activities is embedded into daily activities. The training consisted of 7 balance activities and 9 strength activities. The participant chose which type of activities they would perform. LiFE participants performed 11.2 LiFE activities per week. Strength activities were selected more frequently and performed by more participants on more than four days per week. Participants who performed LiFE balance/strength activities less than 4 days a week, are classified as none-performers. Participant who performed LiFE balance/strength activities for 4-7 days per week can be compared to those performing a structured training program 2-3 days per week. These are considered medium-to-high performers. In total they had the opportunity to perform 16 LiFE activities. On average, the LiFE participants maintained their baseline value in the 8-level balance scale. The medium-to-high strength performers

performed better in all 3 domains, compared to none-to-low performers. The participants who also rated the program safe and felt safe performing the activities also performed better. Study did not mention any form of fall data.

Article 7: Rogers et al. (2021) looked at comparison of lateral perturbation-Induced Step Training and Hip Muscle strengthening exercise on balance and falls in community-dwelling older adults. 102 participants with a mean age of 73, were randomly divided in to four different training groups. The groups were; Induced Step Training (IST, n=25), Hip Abduction Strengthening (HST, n=25), Combined Training (CMB, n=25) who included both IST and HST and the CG performed seated flexibility/relaxation (SFR, n= 27). Balance and strength were assessed prior to the training period (baseline) and 3 months after ended training period. Balance was assessed using Berg balance scale, the Four-square step test (FSST) and the Activities-specific balance Confidence Scale. Protective stepping was evaluated using lateral postural perturbations applied via a motorized waist-pull system. Outcome of this test measured the Balance Tolerance Limit (BTL), defined aa the minimum perturbation intensity at which the recovery steps was greater than one. Activities-specific balance confidence scale was not defined in this study. Falls were tracked in 12 months after training period.

Training period consisted of 36 sessions conducted 3 times per week. IST group used the same method of training as the lateral postural waist-pulling tests. HST group performed 3 resistance exercises focused around the hip. CMB group trained both IST and HST and the protocols were the same. SFR (CG) training involved minimal intensity flexibility and relaxation exercises while seated. After 12 weeks of training program, the participants were encouraged to perform a home-based maintenance program 2-3 times a week.

Balance tolerance limit had a significant improvement within the CMB and IST groups. BTL did not differ between HST and SFR groups. However, this result was borderline significant when adjusted for group difference at baseline. Number of lateral recovery steps improved in both CMB and IST. Only the CMB showed a significantly larger increase in the rate of lateral steps than the control group. Isolated hip strength training was not effective in improving protective recovery steps or balance tolerance. However, all 3 intervention groups showed

significantly fewer falls than the CG. CMB showed the greatest improvements on all measurements.

Article 8: Clemenson et al. (2012) studied the integration of balance and strength training into daily life activities to reduce rate of falls in older adults. This study also used the LiFE program as mentioned above. Mean age of all the participants were around 83 years old. Participants were divided randomly into three different groups. One group conducted the LiFE program (n=107), one performed structured exercise (n=105) and the CG performed gentle exercise (n=105). Assessments of all participants were made at baseline, six months, and 12 months after randomization. Falls were self-reported during the intervention period. Static and dynamic balance was assessed using two hierarchical balance scales. The first is a five-level scale from the physical performance battery-balance test, and the second was an eight-level scale that challenged the participants furthermore. Participants did a survey about activities specific balance confidence scale. LiFE group followed the same LiFE program as mentioned in (Gschwind et al., 2013). The group performing the structured program was asked to perform the program three times a week. Program had seven exercises for balance and six for lower limb strength. Both LiFE and structure program groups performed the program in six months. CG performed 12 gentle and flexibility exercises while seated, laying down or standing while holding on. The control program did not increase the difficulty in any way.

LiFE and the structured program group showed a great improvement within the two balance scales. These two groups also had a significant gain in Balance confidence. Knee and hip strength changes were not significant for either program, due to CG also made some improvements. The overall incidence of falls at 12 months in the LiFE program, was 1.66 per person years, compared with 1.90 in the structure program and 2,28 in the CG. This was a significant change. There was no statistically significant result between the structure group and the CG regarding falls.

Table 1: Overview of all included studies

Article	*Study design*	*N*	*Intervention*	*Tests*	*Main results*
(Mora Pinzon et al., 2019)	Single arm clinical trail	IG: 24 No CG	IG: TD: 2,5 h, TF: weekly, TP: 8 sessions, TT: S + B training and EC	TUG FaB scale	TUG had a non-significant increase in completion time. FaB scale improved significantly on average. Number of falls recorded did not decrease significantly.
Zhuang, Huang et al., (2014)	RCT	IG: 22 CG: 28	IG: TD: 60-minute sessions, TF: 3 times per week, TD: 12 weeks, TT: B + S + Tai Chi CG: Usual care	CS-30, TUG, FR, SEBTs, Isokinetic strength	CS-30 ,TUG and SEBT significant improvements, FR was not significant, isokinetic strength non-significant improvement. Improved fall-related physical performance.
(Jensen et al., 2004)	RCT	IG: 89 CG: 98	IG: TF: Recommended 2-3 times a pr. week, TP: 11 weeks, TT: B + RT + Gait speed + EC CG: Usual care	FAC scale, gait speed, Berg Balance Scale, Step height	Positive effects on gait speed and step height, no significant change in Berg balance Scale Benefits where found, but not statistically significant improvement in recorded falls at 9 months between groups.
(Ohtake et al., 2013)	RCT	IG: 110 CG: 86	IG: Health EC, TF: once a week (twice a week at home), TP: 8-weeks, TT: stretching + S + B CG: health EC	Balance assessments, TUG, FRT, fall prevention self-efficacy scale	FPSE and FR had significant improvements, no other physical assessment improved statistically. Difference in falls recorded was not statistically significant.
Ambrose, Teresa Liu et al., (2019)	RCT	IG: 173 CG: 172	IG: TF: 3 times a week, TP: 12 months, TT: B + S CG: Usual care	Self-reported falls, change in fall risk, TUG	Reduction in falls was observed, although physical assessments did not improve significantly.
(Nerz et al., 2022)	Single-blinded trial	IG: 252 No CG	CG: TP: 6 months LiFE training, TT: B + S	8 level balance scale, 30-CS, accelerometer	S activities were more selected than B. Those who prioritized B scored better in the balance and PA domain. Those who prioritized S scored better in all three outcomes. Did not mention some sort of fall data.
Rogers, Mark W. et al., (2021)	RCT	IG: 76 CG: 26	IG: TP: 12 weeks, TF: 36 sessions in total. 3 different TT: IST, HST, CMB CG: Flexibility + relaxation	Recovery steps, BTL, Berg Balance Scale, Hip S, fall frequency	BLT significant change in two groups. Fall frequency decreased the most in CMB and IST groups. All 3 IG had significantly fewer falls.
Clemson, Lindy et al., (2012)	RCT	IG: 212 CG: 105	IG: TF: 3 times a week, TP: 6 months, 2 different TT: LiFE and structured B + S program CG: gentle workout	Fall rate, Battery Balance-test, activities specific balance confidence scale, lower limb strength	LiFE and B+S program improvement in balance scale and balance confidence. Knee and Hip was not statistically significant. LiFE showed significant decrease in fall rates.

Note: RCT= Randomized Control Trial, B=Balance, S=Strength, EC=Education, TP=Training period, TF=Training frequency, TD=Training duration, TT=training type, RT= Resistance Training,

4. Discussion

Our eight included studies have investigated the effect of strength- and balance training focusing on fall prevention as the main outcome variable. Based on the results of the studies strength- and balance training improved in all intervention groups, but only Rogers et al. (2021) and Clemson et al. (2022) had statistical significant decrease in fall rates.

4.1 Forming habits and long term effects

The duration of intervention period varies within our included studies. The LiFE studies Nerz et al. (2022) and Clemson et al. (2012) conducted a home-based exercise program where intervention lasted for respectfully 6 months and 12 months. Liu-Ambrose et al. (2019) performed a home-based strength and balance program which also lasted 12 months. Our other included studies had considerable shorter intervention periods though. The duration of the intervention periods of Rogers et al. (2021) and Zhuang et al. (2014) lasted for a period of 12 weeks, Jensen et al. (2004) 11 weeks, and the intervention period of Pinzon et a. (2019) and Ohtake et al. (2013) lasted for only 8 weeks.

Only studies in which the intervention lasts for 8 weeks or more should be considered generalizable and thus reliable (Marek, 2019). Also, classic strength training is usually performed for 8 to 12 weeks, with a more sustained effect from a longer training period (Mayer et al., 2011). We also know that it on average takes on average 66 days with a range from 18 to 254 days to form a new habit. It can vary considerably and can take a long time for people to reach their highest level of automaticity. Hence creating new habits requires self-control to reach the desired behavior and has to be maintained for a significant period before the behavior can be performed automatically (Lally et al., 2010). What this means is that the longer an intervention period lasts, the better. The formation of habits is also very subjective and can vary from one person to the other, since it depends on various factors such as intra-personal characteristics and external circumstances (Lally et al., 2010). According to this, it´s quite variable whether a person learns a new habit in a fast or slow matter. This considered, it is better to facilitate and integrate strength- and balance exercise for a long duration of time in a study rather than just a few weeks. This is because the participants of the study will have more time to properly learn the training methods and techniques and preserve what they´ve learned so that it later, after the study can be integrated in older people's lives and become a habit.

There is a reason to why it is beneficial for a study to last over a longer duration of time in addition to habit formation itself. The habit of integrating strength- and balance training into everyday life after the intervention period is finished, is beneficial because it has a positive effect in the long run. Community-dwelling older adults who practiced doing supervised strength and balance training once a week for over 2 years experienced the program helped to prevent age-related decline in mobility and muscle strength (Aartolahti et al., 2020). Fall prevention can be viewed as a maintenance of mobility. Aartolahti and associates further states that even small increments in strength and balance training could help maintain older adults´ independent mobility. In other words, it does not demand a lot to help prevent age-related decline and some training is better than no training at all. 2 studies did not have a follow-up period, 2 studies had 6 months follow-up, one had 9 months and 3 studies investigated long term effects after 12 months. It is most beneficial to have a long intervention period and follow-up time to best investigate an effect, and to integrate the training into everyday life. Our studies do in some degree support this theory. Nerz et al. (2022) states that trainers should push the participants to challenge themselves. Follow-up practice in the included studies was occasional visits by study personnel or phone calls. It can be discussed that after a while participants motivation decreased due to lack of interaction with study personnel which again could have affected end-results negatively.

4.2 The older population

An older person is above 60 years old. The older population is also a very heterogenous group of people, where the large diversity originates from people´s physical and social environments and the impact these environments has made on opportunities and health behavior through life (World Health Organization, 2022a). We were interested in researching older people in general with all diversity included. Of the 8 included studies, 7 included different community dwelling older adults, meaning old people that live outside care facilities to their studies, while 1 (Jensen et al., 2004) conducted their study on old people living in residential care facilities in Sweden. This skewed distribution of selection is maybe due to the complexities that may occur in performing strength and balance training within a frail population. What is interesting though is that if researchers choose to only conduct studies on the healthiest older people, a significant proportion of the older population does not get investigated and thus does not receive efficient training to prevent falls and improve their quality of life. Furthermore, participants with cognitive impairment were excluded in the 7 studies including community

dwellers. Jane Jensen et al. (2004) on the other hand included participants with mild to severe cognitive impairment. They claimed that old people with cognitive impairment should not be excluded from fall prevention studies since maintaining physical function and well-being is beneficial for them, as their results also show for (Jensen et al., 2004). When certain people within a group are being excluded from a study, their effects are not investigated and moreover the diversity of the term "older people" gets curtailed.

4.3 Significant fall prevention

In our included studies, only 2 out of 8 original articles showed a statistically significant decline in the number of falls reported in the different follow-up times. What could this be due to? Primarily, sample size is worth mentioning. Our included studies vary tremendously in number of participants. From 24 (Mora Pinzon et al., 2019) to 345 (Liu-Ambrose et al., 2019). We have a population, a target population which in this article is older people and the study population within the studies. To achieve the greatest design effect in a study with high homogeneity, it is required to have a great sample size to increase precision (Martínez-Mesa et al., 2014). Especially if the participants are a particular group of similar people the study population is recommended to increase study population for it to be significant for the target population. Our included studies have a narrow range when considering older people as a totality because they investigate a group of older people and have strict inclusion and exclusion criteria. They do cover both community dwelling older adults and older people in care facilities, but many studies still have a small sample size and can´t be seen as representative for older people as the target population. This may be a reason for the non-significant decline in fall rates for some studies.

Another possible reason for the fall rates after intervention is the many reasons why older people fall. A fall is as we know defined as "events that resulted in a person coming to rest unintentionally on the ground" (Rogers et al., 2021). Meaning all unintentional events from simply losing balance to acute illness. A lot of things can lead to the event of a fall (National Institute on Aging, 2022), hence the falls reported in the studies does not have to be a direct cause of the lack of balance or missing substantial strength in the lower extremities.

4.4 Strengths and weaknesses with the included studies

One weakness found in many of our studies is the self-reported questionnaire form of collecting data. Self-reported characteristics through a characteristics table found in all the studies is often valid because it involves personal questions which most likely is correct because it is well known information. Nevertheless, a subjective questionnaire or phone call in the follow-up time during the study can often be under- or overreported. Questions like how much training has been done or how many falls in a certain period can serve as a confounding factor in terms of false reporting or recall error. One strength with the included studies is that 6 of 8 studies are RCTs. RCT studies are the gold standard in experimental studies where the effect of a measure is investigated. These studies have a high internal validity because of the strict criteria set for inclusion and exclusion and the randomization (Jong et al., 2015). Because our target group is older people, both the internal and the external validity is quite high given the fact that our studies include both healthy older people in addition to older people living in care facilities or participants that had normal or injurious falls prior to participation in the studies.

5. Conclusion

To summarize, we conclude that there are not enough statistically significant decreases in fall rates in the included studies to claim that strength- and balance training has a positive effect on fall prevention because of factors discussed above. However, almost every IG have some sort of significant improvements on fall-related physical assessments. Due to these improvements, we choose to assume that strength- and balance training have effect on fall prevention, but there are more factors that cause falls which is not counted for.

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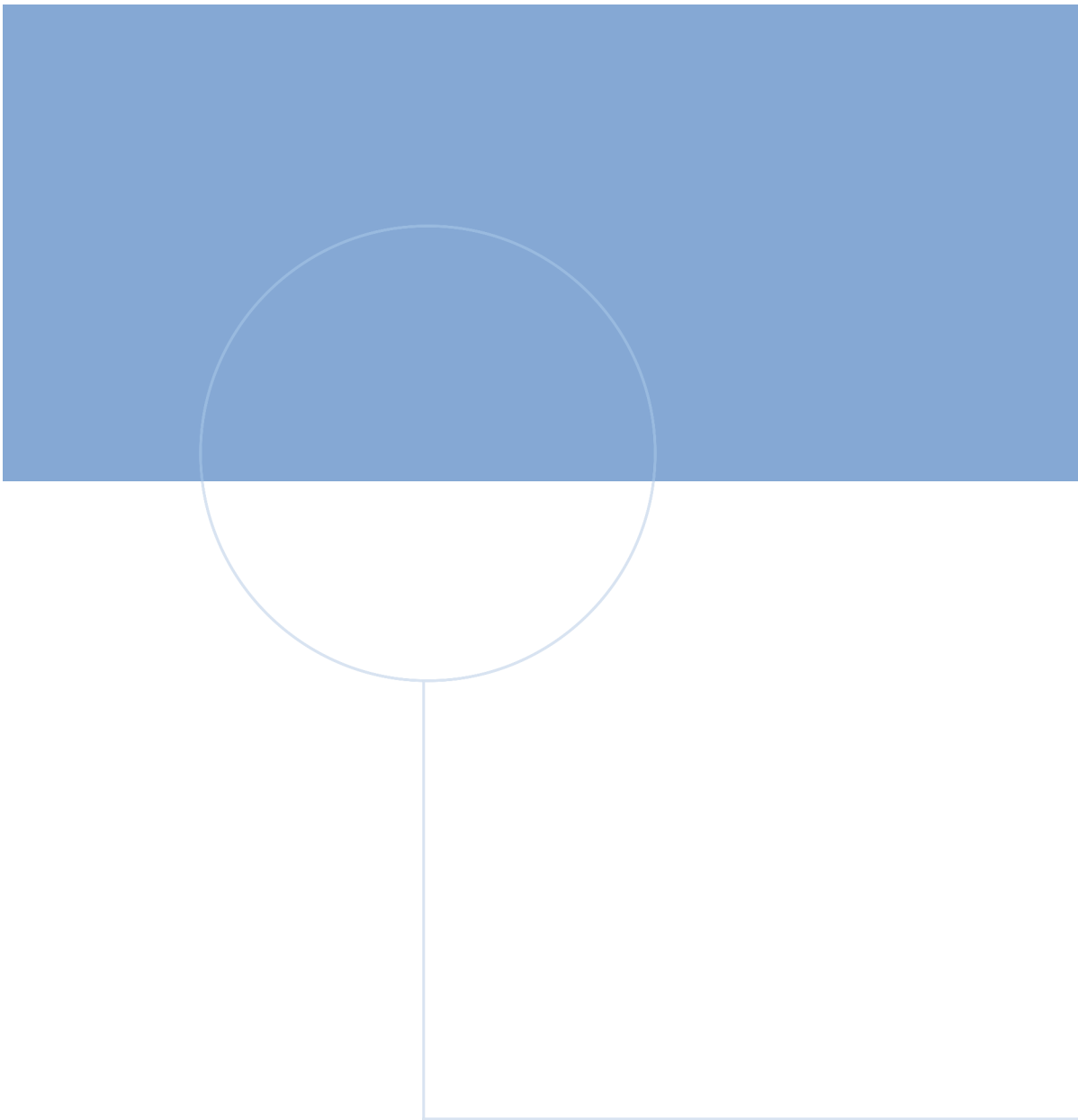

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