



Published in final edited form as:

Qual Ageing. 2009 November 20; 10(4): 37–48.

The effects of 8-week balance training or weight training:

For the elderly on fear of falling measures and social activity levels

Sukwon Kim[Assistant Professor],
Texas A&M University-Commerce

Thurmon Lockhart[Associate Professor], and
Virginia Tech, USA

Karen Roberto[Professor]
Center for Gerontology, Virginia Tech, USA

Abstract

The purpose of this study was to examine the influence of participating in an 8-week physical training (ie: balance or weight training) on psychosocial outcomes for independently living healthy older adults. Eighteen older adults (65 years old or older) voluntarily participated for this study. Participants were randomly and evenly distributed in 3 different groups such as balance, weight, or control group; 6 participants each. Fear of falling and social activity levels were statistically tested by evaluating questionnaires validated in previous studies. Psychological factors improved in all groups after 8 weeks ($P < 0.05$). Social interaction level did not improve in any of the three groups, although all participants exhibited improvements in being physically independent ($P < 0.05$). Results suggested that being physically active as well as being socially active could result in being less fearful of falls, more confident of leaving residency, being more independent, and being more active.

Keywords

weight training; balance training; fear of falling; social interaction; independency confidence

INTRODUCTION

Falls are a result of complex integration of physical, psychological and social factors among older adults (see Figure 1). They represent a major health hazard for older adults that have a significant influence on the well-being and quality of life of those older adults and their family (Huang *et al*, 2003).

As the human body ages, the neuromusculoskeletal component continues to deteriorate. Ageing in the neuromuscular system contribute to limb immobilization and poor health status (Lockhart *et al*, 2002 & 2003; Newman *et al*, 2003; Wolfson, 2001). More interestingly, problems with mobility and poor health status are closely related to the frequency of falls (Chang *et al*, 2004; Gardner *et al*, 2002; Khuvasanont & Lockhart, 2002; Kim *et al*, 2005). Many older adults often reduce their daily activities (i.e. gardening, going up and down stairs, driving, shopping, and walking) after experiencing an initial fall due to the fear of falling; and older adults fear falls more than younger adults (Brown *et al*, 2002;

Fletcher & Hirdes, 2004; Huang H *et al*, 2003; Oliver *et al*, 2004; Tinetti, 2003; Yardley & Smith, 2002). Li *et al*, (2003) identified fear of falling as a key public health concern and stated: ‘Fear of falling can result in self-induced restrictions in activity that could lead to muscle and lower-extremity strength depletion, thus restricting mobility and consequently reducing physical functioning.’

In addition to psychological issues, such as the fear of falling, a decrease in involvement in social activities visiting friends or relatives, going to the store, walking outside, and going to a place with crowds, is also of concern for older adults and their families. Older adults with diminished physical and functional abilities who also express a fear of falling are less likely to engage in social activities (Gill *et al*, 2004; Li *et al*, 2002; Oliver *et al*, 2004). The physical activity level of older adults is also a reflection of their attitudes, self-efficacy, and support from family members and friends (Booth *et al*, 2000; Brouwer *et al*, 2003; Cumming *et al*, 2000; Li *et al*, 2002).

The changes in neuromusculoskeletal components with advancing age contribute to a decreased physical capability such as a reduction in lower extremity strength (Ferrucci *et al*, 2002; Newman *et al*, 2003; Rantanen, 2003) and insecure and unconfident balance leading to unstable dynamic postural control and poor gait dynamics (Judge, 2003; Khuvasanont & Lockhart, 2002; Lockhart *et al*, 2003; Wolfson, 2001). Unstable dynamic postural control and poor gait dynamics influence the likelihood of falls among older adults (Judge, 2003; Lockhart *et al*, 2002 and 2003; Kim and Lockhart, 2008). One common factor that may be improved to decrease the falls rate is to improve the physical and functional capability of older adults (see Figure 1). The improvements of physical and functional capabilities of older adults should eventually decrease negative psychological and social factors such as fear of falling and curtailment of daily and social activities that influence the occurrence of falls. However, a question arises regarding how to improve the physical and functional capabilities of older adults. Currently, most interventions to minimise fall accidents among older adults have been focused on the improvement of lower extremity strength (Barnett *et al*, 2003; Woo *et al*, 2007) and balance (Judge J, 2003; Wolf *et al*, 2003). Both exercise training programmes are found to be effective on lessening the degeneration of physical capability contributing to a reduction in fall rates (Barnett *et al*, 2003; Gardner *et al*, 2002; Woo *et al*, 2007). Advantages of strength and balance training among older adults are that it plays a significant role in improving neural recruitment patterns resulting in strength gain (Aagaard *et al*, 2002 Aagaard *et al*, 2003; Mador *et al*, 2004). Strength gain by exercise training plays a role in the improved coordination of other fixator muscles necessary for body support while performing daily tasks such as cooking, gardening, reaching for an object, and walking, and in gaining more coordinated contractions between agonist and antagonist muscle groups leading to greater net force in the imposing movements. The improvement in postural stability while performing daily tasks will eventually lead to a reduction in fear of falling and an improvement in social interactions among older adults (Barnett *et al*, 2003; Li *et al*, 2002; Zhang *et al*, 2006).

Building on the premise that falls among older adults are associated with a tightly knit amalgamation of physiological, psychological, and social factors, we hypothesized that participation in an 8-week physical training (ie. balance or weight training) would influence older adults’ psychosocial functioning. Two questions guided our research.

1. Does participating in an 8-week physical training influence older adults’ fear of falling?
2. Does participating in an 8-week physical training influence older adults’ participation in social activities?

METHODS

Participants

Power analysis was performed to satisfy Type I error of 0.05 and Type II error of <0.35 (Power >0.65) using JMP statistical packages (SAS Institute Inc. Cary, NC, USA). Lower Power (>0.65) was chosen as the acceptable power since the analysis was performed on a 6-week strength training programme (Knight & Kamen, 2001) not 8-week strength training. We assumed that 8-week training could be more effective in improving leg strength than 6-week training.

Each participant completed a consent form approved by the Virginia Tech Internal Review Board (IRB). Participants were excluded from the study if they indicated any physical problems (ie. hip, knee, ankle problems); a questionnaire was used as an initial screening tool. A total of 24 healthy older individuals (2 males and 22 females) were enrolled voluntarily in the study in the first week. After 4 weeks, five people dropped out of the programme leaving seven people in the balance training group, six people in the weight training group, and six people in the control group. For the purpose of this study, one male participant's data were eliminated because his physical abilities were exceptionally superior to the other older participants' physical abilities.

Participants were recruited from the local community by means of advertisements put out by Montgomery Park and Recreation Department in Christiansburg, Virginia. Older adults who had no history of the formal weight and balance exercises in the past six months were identified as eligible participants for this study. They were accepted into the study although they were involved in exercises such as walking, running, swimming, dancing, gardening, tennis, and golf, as long as their physical activities did not involve any intentions that particularly targeted weight lifting and balance control. In addition, participants were allowed to participate in the present study if the length of their exercises targeting improved muscle strength as well as balance did not exceed more than thirty minutes a week in total (ie. for example, weight and balance exercises twice a week for 10 minutes for a session - totalling 20 minutes - were not considered as formal weight and balance training).

To ensure that the weight and balance training group did not engage to any other exercises or physical activities during the 8 week trial, their daily activities were monitored. Also, individuals in the control group were not engaged in any form of exercises or in any form of physical activities; to ensure that occurred, those in the control group were interviewed during the social meetings. To isolate effects of group training among training groups, the control group also met regularly, performed social activities (such as picnics and bingo). Any activity that required physical performance was not included for the control group except for walking. The groups met 3 times a week for 8 weeks. Each meeting lasted between 50–60 minutes. In other words, this study was a 3-group randomised trial.

Treatments for balance, weight, and control groups

Balance training group—Balance training was performed in a multipurpose room at an area recreation center and at the Locomotion research lab at Virginia Tech. A commercial product, Stability Trainer (Thera-Band®, 1245 Home Avenue, Akron, OH 44310), was selected for balance training because Stability Trainer provided three different levels of difficulties (green, blue, and black foams) and controlled exercise intensity for everyone in the group: the experimenters were able to monitor whether each participant's balance was progressing. Stability Trainers were closed cell foam pads with an anti-slip ridged surface and oval foot fitting shape and these features provided an excellent safe exercise environment for older adults. All of the participants were inexperienced in balance training

as well as in the use of a Stability Trainer. They needed to start at an introductory level and progress to the next difficult level in order to prevent injury and maximise the effect. The foam pads were effective for balance training in older adults, especially designed to rehabilitate lower extremities. For the first week, in order for all participants to become familiar with the exercise routines, they were instructed to perform the exercises provided in the instructional manual of the Stability Trainer on firm surfaces such as floors. For the following week (2nd week), participants were evaluated to determine if they were able to perform the exercises at the intermediate challenge level (the green stability trainer). If an individual was not able to perform the exercises safely on the stability trainer, she/he was allowed to perform the exercise on a firm surface until she/he was comfortable and able to move to the green stability trainer. In addition, blue stability trainers (advanced challenge level) were introduced if an individual performed exercises perfectly and confidently on the green stability trainer. Among six volunteers, only 2 progressed to perform the exercises on the blue stability trainer. No upper body exercise was introduced for this particular balance training. The balance exercises are listed in Table 1.

Weight training group—Weight training was performed using the NS-4000 home gym model (Nautilus3, Vancouver, Washington 98684). Weight training in the present study focused on improving lower extremity strength instead of whole body strength concurrent with an exercise regimen developed for balance training. Also, machine weight exercises instead of free weight exercises were used since all the participants were novice to weight training: machine weight exercises were commonly known to be safer than free weight exercises. During weight training, periodized strength training was implemented as it was proven to be more effective in gaining strength than non-periodized strength training (Fleck, 1999). Two different hypertrophy phases was introduced for 5 weeks; 3 sets of 10 repetitions with 50% of maximum exertion for 2 weeks and 3 sets of 10 repetitions for 70% of maximum exertion for 3 weeks. Strength phase lasted for the last 3 weeks; 3 sets of 7 repetitions with 85% of maximum exertion.

Weight training was performed in a weight training room in the Montgomery County Government Center, Christiansburg, VA. Montgomery County Government Center provided NS-4000 home gym model (Nautilus3, Vancouver, Washington 98684) for this study.

All volunteers performed seven weight lifting exercises.

1. Leg extension: target muscle (quadriceps).
2. Seated leg press: target muscle (quadriceps), synergists (gluteus maximus, adductor magnus, and soleus).
3. Calf press: target muscle (gastrocnemius), synergists (soleus).
4. Leg curl: target muscle (hamstring), synergists (gastrocnemius and sartorius).
5. Leg extension: target muscle (quadriceps), synergists (gluteus maximus, adductor magnus, soleus).
6. Hip abduction and adduction: target muscle (gluteus medius, minimus, and maximus), synergists (pectineus, gracilis).
7. Hip extension: target muscle (gluteus maximus), synergists (gluteus medius and minimus).

A 45–60 second resting period was given between each set and a 150–190 second resting period was given between exercises. No upper body exercise was introduced for this particular weight training.

Control group (social activity group)—Members of the control group also met three times a week for 8 weeks in accordance with the balance and weight training groups. Control group members met and engaged in social activities such as picnics, bingo, shopping and park visits. The local Department of Parks and Recreation provided the activities for seniors. The purpose of introducing social activities for the control group was to isolate and signify the effects of physical treatments on psychosocial characteristics of the older participants. Based on the research literature, it was hypothesized that meeting as a group would have an impact on social as well as psychological factors of older participants. Training groups would naturally have additional treatment such as motivation, competition, and cooperation besides weight and balance training since they were to exercise as a group. To isolate these confounding variables, the control group also was to meet regularly as training groups. However, any activity that required physical performance was not included when the control group met.

Questionnaires (psychosocial factors)—Psycho-social variables for all groups (weight, balance, and control groups) were assessed (or one could say ‘measured’) at pre- and post-training. A fear of falling (psychological) (Friedman *et al*, 2002; Howland *et al*, 1993 & 1998) and a portion (social) of Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaires (Harada *et al*, 2001) were used to evaluate psycho-social aspects, respectively.

The fear of falling measure consisted of one yes/no question (ie. the number of falls within the last 12 months) and two rating scale items (ie. daily activity level and fear of falling): continuous rating scales (1–10, 10 being high) were used instead of rating scales with anchors used in Howland *et al*, (1993 & 1998). The rating scale items were measured twice within 10 minute intervals and the two scores were averaged for further analysis. The Social activity questionnaires were adopted from CHAMPS questionnaires (Harada *et al*, 2001). Seven questions assessed psycho-social interactions. Two questions evaluated independencies; for example, participants were asked to rate their level in housework activities. To synchronize anchors in the rating scale with anchors in the fear of falling scales, 1 indicated less interaction and activity, and 6 indicated more interaction and activity (if a participant answer “no” in any question, this automatically is rated as 0 which indicates the least interaction).

Analyses—A 2 (Time; pre and post) \times 3 (Group; weight, balance, and control) mixed factor repeated measure ANOVA was performed by utilizing the JMP statistical packages (SAS Institute Inc. Cary, NC, USA) to evaluate the effects of training on each group. Training was a between-subjects factor and time was within-subjects factors. The p-value was set at $p \leq .05$.

RESULTS

Physical Characteristics (age, height, and weight)

Statistical analysis found no difference in physical characteristics across the three groups (see Table 2).

Psychological factors

After 8 weeks, participants from all groups (balance, weight, and control) were less afraid of falling in the next year (Time, $p = 0.0006$; Group \times Time, $p = 0.76$), were more confident of leaving their homes (Time, $p = 0.001$; Group \times Time, $p = 0.16$), and more active (Time, $p = 0.006$; Group \times Time, $p = 0.97$).

Social factors

After 8 weeks of training, participants indicated that they visited their family or friends more often, attended a concert, movie, lecture, or sport event more often, and did housework more often. Nonetheless, their socialisation characteristics such as attending other group meetings, playing cards, bingo, or board game with other people, and attending church, did not change. There were no interaction effects on any of the questionnaires indicating that weight, balance, and control groups all improved. These results suggested that although participants' physical activity levels improved (ie. visits made to their family members and going-out to attend movie), their socialisation activity levels did not improve (ie. attendance made to club, church or group meetings,) within 8 weeks.

DISCUSSION

The present study evaluated the effects of balance or weight training on psychosocial factors of older adults. Results indicated that after 8 weeks of training all groups including the control group indicated that they were less afraid of falling and more confident about being active, however, socialisation activities did not increase. Although after 8 weeks of training or social meeting, participants were more physically active, there was no significant change in their levels of social activity. Although tested, the perceived lack of opportunities for social engagement may have contributed to no change in the older adults' social activity. During informal conversations with the trainer, the older participants reported that although they were attempting to be more active, there were few events available for them to socialise in the local community on a regular basis. Local communities need to ensure that programmes and events are well publicised in order to encourage greater participation of older adults in age-targeted as well as age-neutral opportunities.

In agreement with previous studies (Chandler *et al*, 1996; Lawrence *et al*, 1998; Myers *et al*, 1996; Tinetti *et al*, 1988), the fear of falling was a common response of elders at the pre-training stage. The present study suggested that, after 8-week physical training, these participants indicated they were less afraid of falling. The fear of falling among older people can compromise socialisation (Howland *et al*, 1998) thereby increasing isolation, depression, and anxiety (Arfken *et al*, 1994) and contribute to increased risks of falling. People with the fear of falling tend to curtail or stop socialisation because of being afraid of falls (Arfken *et al*, 1994; Chandler *et al*, 1996; Howland *et al*, 1998; Li *et al*, 2002). Curtailment often leads to a decrease in physical capability and depression due to lack of socialisation, in turn facilitating physiological ageing more rapidly in comparison to active older adults (Chandler *et al*, 1996). However, those with the support of family or friends continue to do daily activities (Howland *et al*, 1998). This may indicate that encouragement from family members or friends is important for the elderly to continue to remain active (Howland *et al*, 1998).

Older adults who participate in regular activities have better physical and psychological health (McAuley & Rudolph, 1995; Spirduso, 1995; American College of Sports Medicine, 1998). Motivational orientations such as family support and self-efficacy to exercise among older people have been suggested to be an important factor that assists and facilitates remaining active while ageing (Duda and Tappe, 1989; Dziewaltowski, 1989; Howland *et al*, 1998). Exercise behaviours and habits among the elderly can be determined mainly by self-motivational constructs, self-efficacy, expectations of health benefits, spouse support, family and peer influences, and accessibility to facilities (Booth *et al*, 2000; Duda and Tappe, 1989; Dziewaltowski, 1989; Howland *et al*, 1998; Sallis & Owen, 1999). The older adults who believe more strongly that physical activity improves health, who have foot paths in their residential area that present fewer obstacles to safe and comfortable walking, and who live closer to facilities are more active than the older adults without those amenities (Ajzen,

1991; Booth *et al*, 2000; Duda & Tappe, 1989). Additionally, older adults who receive support to be active from family and friends and have high self-efficacy for physical activity are more likely to be involved in exercise programmes and social meetings, consequently succeeding to improve the quality of life (Booth *et al*, 2000; Li *et al*, 2002).

The findings of the present study suggested that weight or balance training improves the quality of an older adult's life by helping them to lessen the fear of falling. After 8 weeks, participants were very happy to be involved in this study although they were not certain about what training would have done for them. Most of the participants indicated they were happy to meet and to do exercise or socialisation regularly. They indicated they enjoyed the programme very much and they wanted the study to continue.

As discussed previously, a fall is an outcome of an amalgamation of physiological, psychological, and social factors. The findings from this study suggested that the improvements of physical and functional capabilities of older adults should eventually decrease negative psychological and social factors such as fear of falling and curtailment of daily and social activities that influence the occurrence of falls. Currently, most interventions to minimise fall accidents among older adults have been focused on the improvement of lower extremity strength (Neil, 1994) and balance (Judge, 2003). An exercise training programme is found to be effective on lessening the degeneration of physical capability contributing to a reduction in fall rates (Campbell *et al*, 1999; Gardner *et al*, 2002). Advantages of strength and balance training among older adults are that it plays a significant role in improving neural recruitment patterns resulting in strength gain (Aagaard *et al*, 2002; Aagaard *et al*, 2003; Mador *et al*, 2004). Moreover, strength gain by exercise training plays a role in the improved coordination of other fixator muscles necessary for body support while performing daily tasks such as cooking, gardening, reaching for an object, and walking, and in gaining more coordinated contractions between agonist and antagonist muscle groups leading to greater net force in the imposing movements (Jones *et al*, 1989; Rutherford and Jones, 1986; Sale 1988). Simply, the above studies (Fiatarone *et al*, 1990; Jones *et al*, 1989; Rutherford & Jones, 1986; Sale 1988) suggest that exercise training results in improving postural control while performing daily tasks.

LIMITATIONS

The threats to external validity may have been observed because lower statistical power (0.65) was accepted for the present study: the drop-out rate could not be anticipated. It was imperative to start the training programme immediately after the introductory meeting. The experimenter could not push back the programme start-date for additional participants: there were twenty-four volunteers to start with. In fact, many volunteers would have dropped out if training was postponed for additional participants. *In the future, higher statistical power should be used so that the probability of a statistical significance test rejecting the null hypothesis for a specified value of an alternative hypothesis will be appropriate.*

Another limitation could have come from an inability to balance out gender across the groups. As discussed earlier, the experimenter was not allowed to postpone the programme for additional volunteers because the volunteers from the introductory meeting had to organise regular hours for the social activities or exercise training sessions in advance. It was very difficult to organise regular hours for these activities and training because everybody had their own schedule to work with: some of them had part-time jobs and some of them engaged in volunteer work. Data among seventeen females and one male were evaluated to test the hypotheses in the present study. The uneven numbers in gender could lead to a generalisation problem when generalising the results of the present study to all

female and male adults over 65 years old. *In the future, study should either balance out gender or investigate the gender effects of this training.*

A large age range was a limitation for the present study. All participants were aged 65 and older and came from Montgomery County, Virginia. Still, participant age ranged from 66 to 82. This large range of age could decrease the possibility for generalisation of the results. *In the future, the age range should be minimised or participants should be distributed among narrower age groups such as 65–69, and 70–74, and 75–79 etc.* This could be more difficult as explained in method section, but, this could improve the study's generalisability. Differences in their physiological ageing process level may have influenced their ability to adapt to training programmes or to bring bias into the experiment. In other words, one group's learning curve for training may have been different from the other group.

Threats to internal validity (ie. selection bias) may have existed in the present study. When treating multiple groups with different training programmes, all the groups must be comparable to each other because one group may respond differently to a particular intervention than the other. Height, weight, and age across the three groups in the present study were not significantly different (Table 2) although their education level, attitude, personality, motor ability, and mental ability were not statistically tested to suggest whether those groups were properly comparable. These similarities in physical figures may have minimised the threat to internal validity. Possible differences in education level, attitude, personality, motor ability, and mental ability may have influenced measures while responding to questionnaires. *Ideally, in the future, more comparable individuals should be tested to minimise the selection bias.*

References

- Aagaard P, Simonsen EB, Andersen JL, Magnusson P, Dyhre-Poulsen P. Increased rate of force development and neural drive of human skeletal muscle following resistance training. *Journal of Applied Physiology* 2002;93(4):1318–1326. [PubMed: 12235031]
- Aagaard P, Simonsen EB, Andersen JL, Magnusson P, Dyhre-Poulsen P. Neural adaptation to resistance training: changes in evoked V-wave and H-reflex responses. *Journal of Applied Physiology* 2002;92:2309–2318. [PubMed: 12015341]
- Ajzen I. The theory of planned behavior. *Organizational Behavior and Human Decision Making Processes* 1991;50:179–211.
- American College of Sports Medicine (ACSM). Position stand: Exercise and physical activity for older adults. *Medicine & Science in Sports & Exercise* 1998;30:992–1008. [PubMed: 9624662]
- Arfken CL, Lach HW, Birge SJ, Miller JP. The prevalence and correlates of fear of falling in elderly persons living in the community. *American Journal of Public Health* 1994;84:565–570. [PubMed: 8154557]
- Barnett A, Ben S, Stephen R, Mandy W, Adrian B. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomised controlled trial. *Age and Ageing* 2003;32:407–414. [PubMed: 12851185]
- Booth M, Owen, Bauman A, Clavisi O, Leslie E. Social-cognitive and perceived environment influences associated with physical activity in older Australians. *Preventive Medicine* 2000;31:15–22. [PubMed: 10896840]
- Brouwer BJ, Walker C, Rydahl S, Culham E. Reducing fear of falling in seniors through education and activity programs: a randomized trial. *Journal of the American Geriatrics Society* 2003;51:829–834. [PubMed: 12757571]
- Brown LA, Sleik RJ, Polych MA, Gage WH. Is the prioritization of postural control altered in conditions of postural threat in younger and older adults? *Journal of Gerontology Series A: Biological Sciences and Medical Sciences* 2002;57:785–792.
- Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Falls prevention over 2 years: a randomized controlled trial in women 80 years and older. *Age and Ageing* 1999;28:129–138.

- Chandler JM, Duncan PW, Sanders L, Studenski S. The fear of falling syndrome: Relationship to falls, physical performance, and activities of daily living in frail older persons. *Topics in Geriatric Rehabilitation* 1996;11:55–63.
- Chang J, Sally CM, Laurence AR, Walter AM, Margaret M, Marika JS, Elizabeth AR, Paul GS. Interventions for the prevention of falls in older adults: systematic review and meta-analysis of randomized clinical trials. *British Medical Journal* 2004;328:680–686. [PubMed: 15031239]
- Gill TM, Allore HG, Holford TR, Guo Z. Hospitalization, restricted activity, and the development of disability among older persons. *Journal of the American Medical Association* 2004;292:2115–24. [PubMed: 15523072]
- Cumming R, Salkeld G, Thomas M, Szonyi G. Prospective study of the impact of fear of falling on activities of daily living, SF-36 scores, and nursing home admission. *Journal of Gerontology: Medical Sciences* 2000;55:299–305.
- Duda, JL.; Tappe, MK. Personal investment in exercise among adults: the examination of age and gender-related differences in motivational orientation. In: Ostrow, AC., editor. *Aging and Motor Behaviour*. Indianapolis (IN): Benchmark Press; 1989. p. 239-56.
- Dzewaltowski, DA. A social cognitive theory of older adults exercise motivation. In: Ostrow, AC., editor. *Aging and Motor Behaviour*. Indianapolis (IN): Benchmark Press; 1989. p. 257-81.
- Fleck, Steven. Periodized strength training: a critical review. *Journal of Strength and Conditioning Research* 1999;13(1):82–89.
- Ferrucci L, Penninx B, Volpato S, Harris T, Bandeen-Roche K, Balfour J, Leveille S, Fried L, Guralnik J. Change in muscle strength explains accelerated decline of physical function in older women with high interleukin-6 serum levels. *Journal of American Geriatrics Society* 2002;50:1947–1954.
- Fletcher P, Hirdes J. Restriction in activity associated with fear of falling among community-based seniors using home care services. *Age and Ageing* 2004;33:273–279. [PubMed: 15082433]
- Friedman S, Munoz B, West S, Rubin G, Fried L. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *Journal of American Geriatrics Society* 2002;50:1329–1335.
- Gardner MM, Phty M, Robertson MC, McGee R, Campbell AJ. Application of a fall-prevention program for older people to primary health care practice. *Preventive Medicine* 2002;34:546–53. [PubMed: 11969356]
- Harada ND, Chiu V, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Medicine and Science in Sports and Exercise* 2001;33(6):962–970. [PubMed: 11404662]
- Howland J, Peterson EW, Levin WC, Fried L, Pordon D, Bak S. Fear of falling among the community-dwelling elderly. *Journal of Aging and Health* 1993;5:229–243. [PubMed: 10125446]
- Howland J, Lachman M, Peterson E, Cote J, Kasten L, Jette A. Covariates of fear of falling and associated activity curtailment. *The Gerontologist* 1998;38(5):549–555. [PubMed: 9803643]
- Huang H, Gau M, Lin W, Kernohan. Assessing risk of falling in older adults. *Public Health Nursing* 2003;20(5):399–411. [PubMed: 12930464]
- Jones D, Rutherford O, Parker D. Physiological changes in skeletal muscle as a result of strength training. *Quarterly Journal of Experimental Physiology* 1989;74:233–256. [PubMed: 2664854]
- Judge J. Balance training to maintain mobility and prevent disability. *American Journal of Preventive Medicine* 2003;25(3):150–156. [PubMed: 14552939]
- Khuvasanont, T.; Lockhart, TE. Age-related ankle strength and the effects on the slip-induced falls. Slips, Trips & Falls III Session 5–4; The Proceeding of the XVI Annual International Society of Occupational Ergonomics and Safety (ISOES); Toronto: Canada. June 9 2002; 2002. p. 1-5.
- Kim S, Lockhart TE, Yoon H. Relationship between age-related gait adaptations and required coefficient of friction. *Safety Science* 2005;43:425–436. [PubMed: 20582254]
- Kim S, Lockhart TE. Effects of 8 week-balance training or weight training for the independently living elderly on the outcomes of induced slips. *The Open Ergonomics Journal*. 2008 (accepted with revisions).

- Knights CA, Kamen G. Adaptations in muscular activation of the knee extensor muscles with strength training in young and older adults. *Journal of Electromyography and Kinesiology* 2001;11:405–412. [PubMed: 11738953]
- Lawrence RH, Tennstedt SL, Kasten LE, Shih J, Howland J, Jette AM. Intensity and correlates of fear of falling and hurting oneself in the next year: Baseline findings from a Royal Center fear of falling intervention. *Journal of Aging and Health* 1998;10:267–286. [PubMed: 10342933]
- Li F, McAuley E, Fisher K, Harmer P, Chaumeton NR, Wilson N. Self-efficacy as a mediator between fear of falling and functional ability in the elderly. *Journal of Aging and Health* 2002;14(4):452–466. [PubMed: 12391997]
- Li F, Fisher K, Harmer P, McAuley E, Wilson N. Fear of falling in elderly persons: association with falls, functional ability, and quality of life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 2003;58:283–290.
- Lockhart TE, Woldstad JC, Smith JL, Ramsey JD. Effects of age related sensory degradation on perception of floor slipperiness and associated slip parameters. *Safety Science* 2002;40:689–703. [PubMed: 20607132]
- Lockhart TE, Woldstad JC, Smith JL. Effects of age-related gait changes on biomechanics of slips and falls. *Ergonomics* 2003;46(12):1136–1160. [PubMed: 12933077]
- Mador MJ, Erkan B, Ajay A, Mary S, Thomas K. Endurance and strength training in patients with COPD. *Chest* 2004;125:2036–2045. [PubMed: 15189919]
- McAuley E, Rudolph D. Physical activity, ageing, and psychological well being. *Journal of Aging and Health* 1995;3:67–98.
- Myers AM, Powell LE, Maki BE, Holliday PJ, Brawley LR, Sherk W. Psychological indicators of balance confidence: Relationship to actual and perceived abilities. *Journal of Gerontology: Medical Sciences* 1996;51A:M37–M43.
- Neil A. Postural control in older adults. *Geriatric Bioscience* 1994;42:93–108.
- Newman AB, Haggerty CL, Goodpaster B, Harris T, Kritchevsky S, Nevitt M, Miles T, Visser M. Strength and muscle quality in a well-functioning cohort of older adults: the health, aging and body composition study. *Journal of American Geriatrics Society* 2003;51:323–330.
- Oliver D, Fergus D, Finbarr CM, Marison ETM. Risk factors and risk assessment tools for falls in hospital in-patients: a systematic review. *Age and Ageing* 2004;33:122–130. [PubMed: 14960426]
- Rantanen T. Muscle strength, disability, and mortality. *Scandinavian Journal of Medicine and Science in Sports* 2003;13:3–8. [PubMed: 12535311]
- Rutherford O, Jones D. The role of learning and coordination in strength training. *European Journal of Applied Physiology* 1986;55:100–105.
- Sale D. Neural adaptation to resistance training. *Medicine & Science in Sports & Exercise* 1988;20:135–145.
- Sallis, JF.; Owen, N. *Physical activity and behavioral medicine*. Beverly Hills (CA): Sage; 1999.
- Spirduso, WW. *Physical Dimensions of Aging*. Champaign (IL): Human Kinetics; 1995.
- Tinetti M. Preventing falls in elderly persons. *The New England Journal of Medicine* 2003;348:42–49. [PubMed: 12510042]
- Tinetti ME, Speechley M, Ginter SF. Risk factor for falls among elderly persons living in the community. *New England Journal of Medicine* 1988;319:1701–1707. [PubMed: 3205267]
- Wolfson L. Gait and balance dysfunction: a model of the interaction of age and disease. *Progress in Clinical Neuroscience* 2001;7(2):178–183.
- Wolf S, Sattin RW, Kutner M, O'Grady M, Greenspan AI, Gregor RJ. Intense Tai Chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial. *Journal of American Geriatrics Society* 2003;51:1693–1701.
- Woo J, Hong A, Lau E, Lynn H. A randomised controlled trial of Tai Chi and resistance exercise on bone health, muscle strength and balance in community-living elderly people. *Age and Ageing* 2007;36(3):262–268. [PubMed: 17356003]
- Yardley L, Smith H. A Prospective study of the relationship between feared consequences of falling and avoidance of activity in community-living older people. *The Gerontologist* 2002;42:17–23. [PubMed: 11815695]

Zhang J, Kazuko I, Hideo Y, Takae M, Toshiki O. The effects of Tai Chi Chuan on physiological function and fear of falling in the less robust elderly: an intervention study for preventing falls. Archives of Gerontology and Geriatrics 2006;42:107–116. [PubMed: 16125805]

Appendix 1. A fear of falling questionnaire (Friedman et al., 2002; Howland, 1998)

1. Falls and fear of falling measure

Question 1 is intended to classify fallers and non-fallers within the sample. Question 2 and 3 is intended to measure degrees of fear of falling among participants whether they are fallers or non-fallers. Question 1 will be used only once before training and answers for question 2 and 3 will be compared between pre and post trainings. 0 in scale indicates more fear of falling and 6 in scale indicates less fear of falling.

Question 1: Have you been fallen within the last 12 months? Falling includes unintentionally coming to rest on the ground or other level such as a chair. (Friedman et al., 2002)

YES

NO

Q2: How afraid are you that you will fall and hurt yourself in the next year? (Mark (i.e. /) a point where it is applicable)

0-----3-----6
Not at all Very Afraid

Q3: Do you ever limit your activities, for example, what you do or where you go, because you are afraid of falling? (Howland et al., 1998) Please read next questions and mark.

You don't leave the residency because are worried that you might fall. (Mark (i.e. /) a point where it is applicable)

0-----3-----6
Less Likely More likely

You stop doing things because you are worried that you might fall. (Mark (i.e. /) a point where it is applicable)

0-----3-----6
Less Likely More likely

Appendix 2. Social Questionnaire (Harada et al., 2001)

In a typical week during the past 4 weeks, did you ...		1	2	3	4	5	6
1. Speak with friends or family (other than those you live with)? <input type="checkbox"/> YES How many TIMES a week? _____→	How often do you speak with friends or family	Less than	1-2 ½ hours	3-4 ½ hours	5-6 ½ hours	7-8 ½ hours	9 or more hours

In a typical week during the past 4 weeks, did you ...		1	2	3	4	5	6
<input type="checkbox"/> NO	(phone and email)? →	1 hour					
2. Visit your friends or family (other than those you live with)? <input type="checkbox"/> YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How often do you visit your friend or family? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
3. Attend other club or group meetings? <input type="checkbox"/> YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How often do you attend club or meeting? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
4. Attend a concert, movie, lecture, or sport event? <input type="checkbox"/> YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How often do you attend a concert, movie, lecture, or sport event? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
5. Play cards, bingo, or board games with other people? <input type="checkbox"/> YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How often do you play cards, bingo, or board games with other people? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
6. Attend church or take part in church activities? <input type="checkbox"/> YES How many TIMES a week? ____ →; <input type="checkbox"/> NO	How many TOTAL hours a week did you usually do it? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
7. Walk <u>to do errands</u> (such as to/from a store)? YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How often did you usually do it? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours
8. Do house-works around the house (such as gardening, sweeping, vacuuming, mowing, cleaning, dish-washing, and dusting etc.)? <input type="checkbox"/> YES How many TIMES a week? ____ → <input type="checkbox"/> NO	How many TOTAL hours a week did you usually do it? →	Less than 1 hour	1–2 ½ hours	3–4 ½ hours	5–6 ½ hours	7–8 ½ hours	9 or more hours

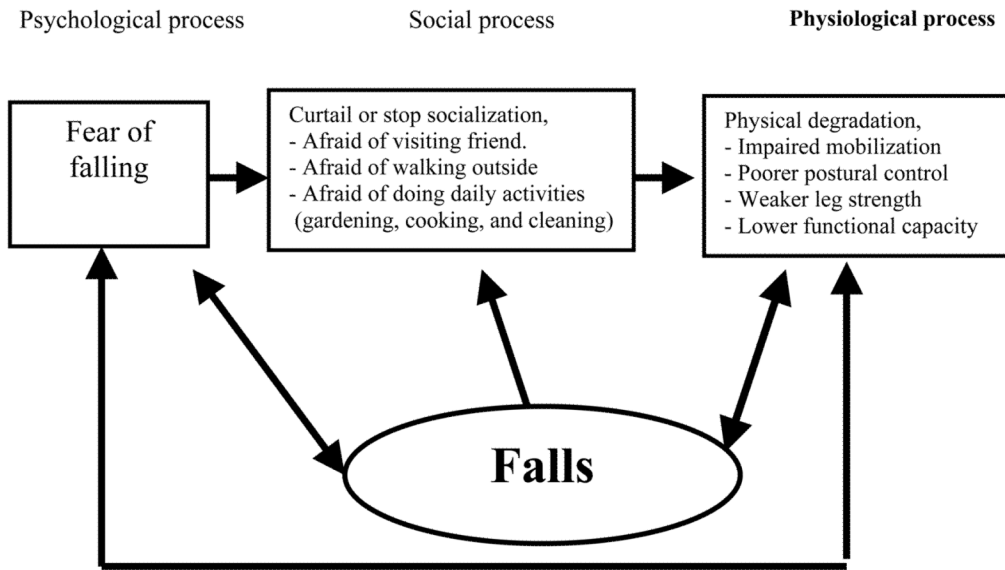


Figure 1.
Interactions among physical, psychological, and social factors.

Table 1

Exercise regimen for balance training with stability trainer

Exercises	Exercise descriptions
Bilateral balance with squat	Standing shoulder apart on the foams with hands on waist, participants bring hip down as low as possible like sitting on a chair while pausing the position for 3 seconds and bring hip up while resting for 3 seconds. Participants repeat the exercise for 10–12 times.
Bilateral calf raises	Standing on the foams with hands on waist, participants raise ankles as high as possible while holding the position for 2 seconds and bring ankle down while resting for 3 seconds. Participants repeat the exercise for 10 times.
Unilateral balance	Participants stand on one leg on the foam. Standing on the foams with hands on waist, participants keep balance as long as possible. Participants repeat the exercise 3 times for each leg
Unilateral calf raises	Participants stand on one leg on the foam. Standing on the foams with hands on waist, participants raise ankle as high as possible. Participants repeat the exercise 10 times for each leg
Unilateral balance with leg backward kick	Participants stand on one leg on the foam. Standing on the foam with hands on waist, participants bring back non-supported leg as much as possible without losing balance and hold the position for 3 seconds. Participants repeat 10 times for each leg.
Unilateral balance with hip flexion	Participants stand on one leg on the foam. Standing on the foam with hands on waist, participants bring forward non-supported leg as much as possible without losing balance and hold the position for 3 seconds. Participants repeat 10 times for each leg
Unilateral balance with knee flexion	Participants stand on one leg on the foam. Standing on the foam with hands on waist, participants flex their non-supported knee about 90° without losing balance and hold the position for 3 seconds. Participants repeat 10 times for each leg.
Kick (abduction and adduction)	Abduction: participants stand on one leg on the foam. Standing on the foam with hands on waist, participants abduct their non-supported leg as much as possible without losing balance and hold the position for 3 seconds. Participants repeat 10 times for each leg. Adduction: participants stand on one leg on the foam. Standing on the foam with hands on waist, participants adduct their non-supported leg as much as possible without losing balance and hold the position for 3 seconds. Participants repeat 10 times for each leg.
Sit-to-stand	While feet are resting on the foam, participants stand up without losing balance from a chair with no help from hands.
Forward reach	While standing on the foam, participants reach an object at their waist height and hold the position for 3 seconds. It is repeated for 10 times.
Lunge	While standing on the floor, step on the foam and lower the body as much as possible. Participants hold the position for 3 seconds and repeat the exercise for 10 times.

Table 2

Descriptive statistics in age, height and weight

	Age	Height (cm)	Weight (kg)
Balance	72.5±6.8	165.7±9.6	70.7±12.0
Weight	72.0±5.5	158.8±2.9	69.39±5.3
Control	76.5±8.3	161.5±9.9	76.0±5.7
P > 0.05	0.48	0.37	0.41