Quality in Ageing and Older Adults

The effects of eight-week balance training or weight training

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The effects of eight-week balance training or weight training

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

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ABSTRACT

The purpose of this study was to examine the influence of participating in an eight-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 in this study. Participants were randomly and evenly distributed in three different groups such as balance, weight or control group; six participants in 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 eight weeks ($P < 0.05$). Social interaction levels 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.

KEY WORDS

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

INTRODUCTION

Falls are a result of a complex integration of physical, psychological and social factors among older adults (see ***Figure 1***, overleaf). They represent a major health hazard for older adults and have a significant influence on the well-being and

quality of life of those older adults and their families (Huang *et al*, 2003).

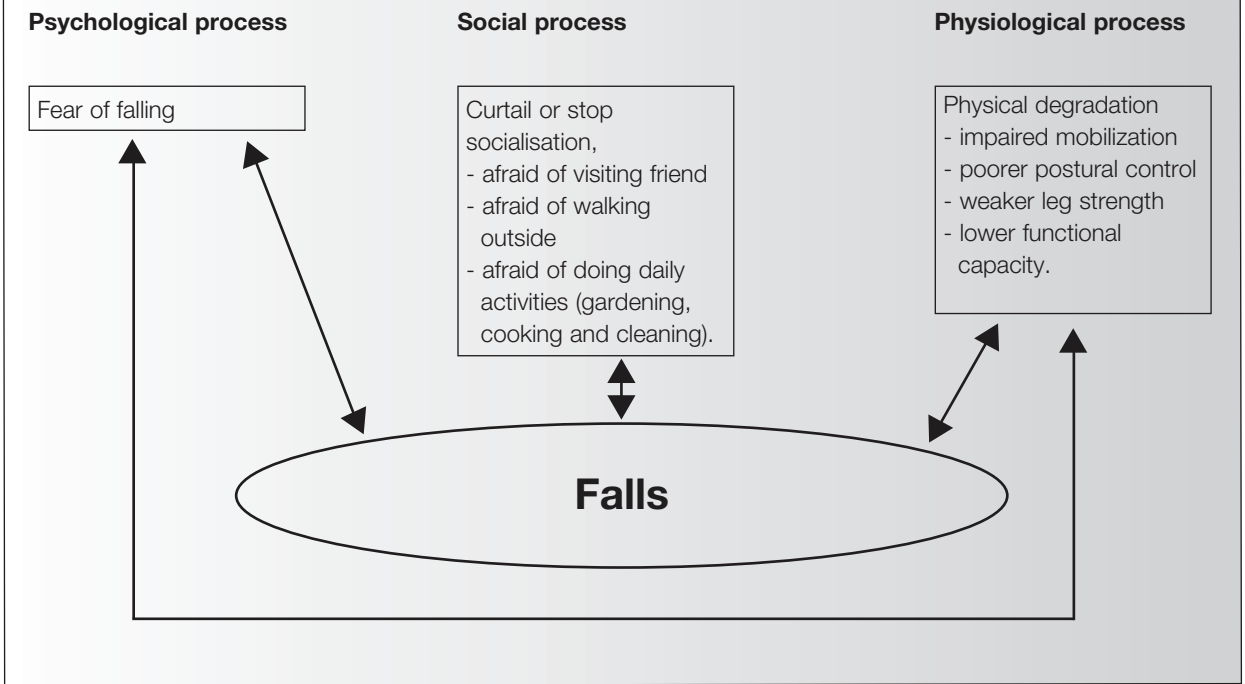
As the human body ages, the neuromusculoskeletal component continues to deteriorate. Ageing in the neuromuscular system contributes to limb immobilisation and poor health status (Lockhart *et al*, 2002; 2003; Newman *et al*, 2003; Wolfson, 2001). More interestingly, problems with mobility and poor health 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 (ie. 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 *et al*, 2003; Oliver *et al*, 2004; Tinetti, 2003; Yardley & Smith, 2002). Li and colleagues (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, such as visiting friends or relatives, going to the store, walking outside, and not 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

Figure 1: Falls: interactions among physical, psychological, and social factors.



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; 2003; Kim & Lockhart, 2009). 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, 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*, 2002a; 2002b; Mador *et al*, 2004). Strength gain by exercise training plays a role in the improved co-ordination 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 co-ordinated 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 hypothesised that participation in an eight-week physical training (ie. balance or weight training) would influence older adults' psychosocial functioning. Two questions guided our research.

1. Does participating in an eight-week physical training programme influence older adults' fear of falling?
2. Does participating in an eight-week physical training programme 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 six-week strength training programme (Knight & Kamen, 2001) not eight-week strength training. We assumed that eight-week training could be more effective in improving leg strength than six-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 (two males and 22 females) were enrolled voluntarily in the study in the first week. After four 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 30 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 in any other exercises or physical activities during the eight-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 and 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 three times a week for eight weeks. Each meeting lasted between 50–60 minutes. In other words, this study was a three-group randomised trial.

Treatments for balance, weight, and control groups

Balance training group

Balance training was performed in a multi-purpose room at an area recreation centre and at the Locomotion research lab at Virginia Tech. A commercial product, Stability Trainers (Thera-Band®, 1245 Home Avenue, Akron, OH 44310), were selected for balance training because Stability Trainers provided three different levels of difficulties (green, blue, and black foams) and controlled exercise intensity for everyone in the group so 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 Stability Trainers. They needed to start at an introductory level and progress to the next difficulty 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 instruction manual of the Stability Trainers on firm surfaces such as floors. For the following week (second 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 Trainers, 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 Trainers. 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 two 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 (Nautilus, 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, periodised strength

training was implemented as it was proven to be more effective in gaining strength than non-periodised strength training (Fleck, 1999). Two different hypertrophy phases were introduced for five weeks; three sets of 10 repetitions with 50% of maximum exertion for two weeks and three sets of 10 repetitions for 70% of maximum exertion for three weeks. Strength phase lasted for the last three weeks; three sets of seven repetitions with 85% of maximum exertion.

Table 1: Exercise regimen for balance training with Stability Trainers

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 three seconds and bring hip up while resting for three seconds. Participants repeat the exercise 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 two seconds and bring ankle down while resting for three seconds. Participants repeat the exercise 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 three 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 three 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 three 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 degrees without losing balance and hold the position for three 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 three 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 three 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 three seconds. It is repeated 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 three seconds and repeat the exercise 10 times.

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 (Nautilus, 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 (gleuteus 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 in 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 eight 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. 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 hypothesised 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 co-operation 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 as regularly as training groups. However, any activity that required physical performance was not included when the control group met.

Questionnaires (psychosocial factors)

Psychosocial 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 psychosocial 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 and colleagues (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 psychosocial interactions. Two questions evaluated independencies; for example, participants were asked to rate their level in housework activities. To synchronise anchors in the rating scale with anchors in the fear of falling scales, one indicated less interaction and activity, and six indicated more interaction and activity (if a participant answered 'no' in any question, this automatically was rated as 0 which indicates the least interaction).

Analyses

A 2 (Time; pre and post) x 3 (Group; weight, balance, and control) mixed factor repeated measure ANOVA was performed by utilising 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 eight weeks, participants from all groups (balance, weight and control) were less afraid of falling in the next year (Time, p=0.0006; Group x Time, p=0.76), were more confident of leaving their homes (Time, p=0.001; Group x Time, p=0.16), and more active (Time, p=0.006; Group x Time, p=0.97).

Social factors

After eight 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 games 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 see movies), their socialisation activity levels did not improve (ie. attendance made to club, church or group meetings) within eight weeks.

DISCUSSION

The present study evaluated the effects of balance or weight training on psychosocial factors of older adults. Results indicated that after eight 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 eight weeks of training or social meetings, 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 activities. 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 eight-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

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

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 & Tappe, 1989; Dzewaltowski, 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 & Tappe, 1989; Dzewaltowski, 1989; Howland *et al*, 1998; Sallis & Owen, 1999). The older adults who believe more strongly that physical activity improves health, who have footpaths 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 eight 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*, 2002a; 2002b; Mador *et al*, 2004). Moreover, strength gain by exercise training plays a role in the improved co-ordination 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 co-ordinated contractions between agonist and antagonist muscle groups leading to greater net force in the imposing movements (Jones *et al*, 1989; Rutherford & Jones, 1986; Sale 1988). Simply, the above studies (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 24 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 17 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, studies 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 66–82 years. 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***, p43) 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.

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