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Original Research Article

Efficacy of Strength and Balance Training Exercise for Fall Prevention in Elderly

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ABSTRACT

OBJECTIVES: To find out the efficacy of strength and Balance training exercise for fall prevention in elderly BACKGROUND: Fear of falling and avoidance of activity are common in old age and are suggested to be (public) health problems of equal importance to falls. Falling represents a significant threat to independence and quality of life (in terms of function, morbidity/mortality for example). Falling is amongst the common causes of injury affecting older people in both residential care and home settings. This study aims at reducing this factor by finding out the efficacy of strength and balance training exercises for fall prevention in elderly
DESIGN: Pre and post test experimental design.
SETTING: Geriatric home and residential societies in and around Bangalore and Jodhpur.
METHODS: This study included 100 subjects with fear of falling, between the age group of 65-80yrs, they were divided into two groups, experimental (strength training and balance exercise) group & control (active ROM exercises training) groups randomly. Experimental group was treated with strength training exercise along with balance training exercises and control group were treated with active ROM exercises training exercises.
Each subject in the experimental group was treated for a period of 6 months with one session of treatment per day for 3 days per week
OUTCOME MEASURE:
Fall efficacy scale
Manual muscles testing (lower limb)
RESULTS: Paired t-test was used for statistical analysis and results showed significant improvement in function and reduction in fear of falling and improvement in lower limb strength in the experimental group $P<0.001$ when compared with control group.
CONCLUSION: This study shows that there is a significant reduction in fear of falling in elderly when strength and balance training exercise was given.

Key Words: Strength training, fall related gait kinematics, Fall efficacy Scale

INTRODUCTION

Fear of falling and avoidance of activity are common in old age and are suggested to be health problems of equal importance to falls. Falling represents a significant threat to independence and quality of life (in terms of function, morbidity/mortality for example). Falling is amongst the common causes of injury affecting older people in both residential care and home settings. 'Fear of falling', or post-fall syndrome as it was initially described (Murphy and Isaacs 1982), is more of a symptom rather than a diagnosis and is characterized by high levels of anxiety related to walking or a fear of falling. [1] Fear of falling and avoidance of activity due to fear of falling are common in older people. Prevalence rates for fear of falling in community-living older persons range from 20 to above 60% [2] and for avoidance of activity due to fear of falling

from 15 to above 55%. Fear of falling, and related avoidance of activity may lead to adverse consequences, like functional decline restriction of social participation, decreased quality of life increased risk of falling and institutionalization and will have societal implications related to health and social care utilization and associated costs. Indeed, fear of falling is suggested to be a potential (public) health problem of equal importance to a fall. [3]

Poor walking performance has previously been associated with older age, increased risk of falling, and greater concern about falling. Changes in spatial and temporal gait parameters in older people due to concern about falling have been demonstrated via reduced speed, shorter stride length, prolonged double-support time increased cadence and increased gait variability. [4]

Among those over the age of sixty-five years, falls represent the most common cause of fatal and non-fatal unintentional injuries. [5] A fall is defined as "an event which results in a person coming to rest unintentionally on the ground or lower level, not as a result of a major intrinsic event (such as a stroke) or overwhelming hazard. [6]

Three of the most common modifiable intrinsic (subject-related) fall risk factors are muscle weakness (relative risk ratio / odds ratio 4.4), balance deficits (relative risk ratio / odds ratio 2.9), and gait instabilities (relative risk ratio / odds ratio 2.9) Balance is important for maintaining postural equilibrium and thus for the avoidance of falls. Aging may affect central nervous system (i.e., changes in brain volume) and neuromuscular system properties (i.e., loss of sensory and motor neurons) leading to deficits in balance and gait performance. [7]

Hence study intended to find the effect of lower limb strengthening and balance training of elderly and to improve fall prevention in elderly and by gaining an understanding of how older adults perceive fall prevention recommendations and how factors influence adherence, health care providers will be better suited to present fall prevention programs for older adults. As older adults develop improved adherence to recommendations for reduced fall risks, it is expected that the numbers of falls experienced will decrease, thereby decreasing the financial impact on the health care system, decreasing the losses of function, and improving the overall quality of daily life for older adults

EPIDEMIOLOGY [8]

- The number of persons above the age of 60 years is fast growing, especially in India. India as the second most populous country in the world has 76.6 million people at or over the age of 60, constituting above 7.7% of total population.
- Over 33% of community-dwelling people aged over 65 years fall at least once a year, and of those 50% will have recurrent falls. [8,9] With increasing age, the rate of falls can increase up to 60%. [7,10]

OBJECTIVES

To find the effectiveness of strength and balance training exercises for fall prevention in elderly.

To compare the effectiveness of strength and balance training exercise with that of Range of motion exercise in fall prevention in elderly.

METHODOLOGY

Research design:

Pre and Post experimental study

Population:

Population for the study included the age groups of 65 years to 80 years. Both male and female subjects were selected

Sample size:

Sample size of 100 subjects was taken for the study.

Sample sources:

The samples were selected from Geriatrics home and residential societies in and around Bangalore.

Sample design:
The sample design followed was convenient sampling with the subjects allocated randomly into 2 groups using a sequential random number generator.

SELECTION CRITERIA:

1. **Inclusion criteria:**

- Age: 65-80
- Diagnosed with fall related gait kinematics according to fall efficacy scale.
- Subjects who experienced at least 2 falls within a period of 6 months before data collection
- Lower limb muscle strength should be 3 or +3 according MMT.
- Ability to engage in dressing, toileting, bathing / hygiene, and self-care transfers is independent or modified independent (may need to use adaptive equipment or durable medical equipment to complete task); no caregivers were required for these tasks.

2. **Exclusion criteria:**

- Vascular lesion e.g. : VBI
- Abnormalities of the skull
- Cerebellar atrophy
- Sensory ataxia
- Benign paroxysmal positional vertigo (BPPV)
- Vestibular neuronitis
- Vascular occlusion
- Meniere's disease
- tumors
- Multiple Sclerosis
- TBI (Traumatic Brain Injury)
- Postural hypotension
- Visual and attention defect
- Fracture (general)
- Any pathological orthopedic conditions, neuropathy and myopathy.

Measurement tools:

Medical history and demographic information such as current health status, lifestyle factors, age, gender and bone medication use was collected through a self-reported medical history form that was administered to the patient at visit one.

FALL EFFICACY SCALE [11,12]

FES is a 10-item rating scale to assess confidence in performing daily activities without falling. Each item is rated from 1 = extreme confidence to 10 = no confidence at all.

Participants who reported avoiding activities because of fear of falling had higher FES scores, representing lower self-efficacy or confidence, than those not reporting fear of falling

MMT [13,14] (Manual Muscle testing Modified from 1993 Florence P. Kendall)

Manual muscles testing done for both lower limb muscles (Illiopsoas, gluteus maximus, medius, quadriceps , Hamstring , Dorsiflexors and plantar flexors) noted and total mean of grade calculated for each lower limb and Grading was noted from 0 to 10.

Where, 0-is no contraction felt

10-is Hold test position against strong pressure

Procedure:

After selection of subjects, the purpose of the study was explained and an informed consent was taken and the procedure was explained with clear instructions. Ethical approval obtained from institutional review board.

The subjects were then randomly assigned into two groups based on random number generator

Strengthening and balancing exercise training includes [15-17]

The exercise program for experimental group contains activities of balance, coordination exercises, strength training, and walking training. In particular, it includes stretching, mini-hurdle walking, zigzag foot walk, ordinary walking, and sit-and-stand up exercises and exercise program for control group contains same exercises program (other than strength and balance training) additionally active ROM exercises for lower limb. The duration of the exercise was approximately one and the half

hour for thrice a week for 12 weeks. The first 2 weeks of exercise was included acclimatization period. The exercises were be divided into five sections: a 5- to 10-minute warm-up period, 15minute strengthening exercise, 10 minute of balance training, 15 minute of gait training, and a 10-minute relaxation (cool down) period. One-to 5-minute rest periods was taken between exercise sections. Blood pressure was recorded as a safety measure only. The exercises will be undertaken as group activities, with a major emphasis on social interaction and enjoyment

GROUP1: experimental group

50 subjects were taken

All the subjects were given Fall efficacy questionnaire and the pre – test scores was determined.

MMT Grade of all the subject was noted.

Exercise protocol

WARM UP PROCEDURE

Warm up exercise was included stretching of lower limb muscles i.e.

Hamstrings, Quadriceps and calf actively

EXERCISE 1

Procedure for hamstring stretching

Starting position:

Subject in erect standing

Stretching:

Subject was asked to bend forwards and try touching the ground without flexing the knee and then to maintain this position for a 30 sec and then come back to the original position. This was repeated for five times.

EXERCISE2

Procedure for quadriceps stretching

Starting position

Subject in erect standing

Stretching

Subject was asked to hold on a fixed support like a chair or a window bar or railing ask him/her to take his/her right leg behind i.e. ask him/her to take his/her hip into extension without flexion of knee and then hold it for 30 counts and then repeat the same for the opposite leg. This was repeated for five times.

EXERCISE 3

Procedure for calf stretching

Starting position

Subject in erect standing

Stretching

Subject was asked to lean against the wall or other stationery object with both the palms against the wall or object. The leg to be stretched was placed back, several feet away from the wall. Subject was asked to lunge forward until the stretch is felt. The same was repeated for other leg with maintenance of stretch for 30 counts and a repetition of five times

Duration of all the above mentioned exercise was 10 min

STRENGTHENING EXERCISES includes

Procedure for closed chain exercise

EXERCISE1

Subject was asked to hold on a stationary object for support and then they were asked to squat partially. They were asked to maintain this position for a count of ten and it was repeated 10 times.

EXERCISE 2

Knee flexion/extension.

The Theraband was looped around right ankle. Subject was made to stand on the other end of the band with his left foot. Subject was asked to hold the back of a chair or a counter for support. Subject was asked to lift his right foot behind until it is at knee level. Then he was asked to lower his foot to the starting position. Exercise was repeated for 10 times

EXERCISE 3

Hip Abduction /adduction

Subject was asked to stand erect then a theraband was looped around right ankle and was asked to move his limb in abduction and adduction .support was given when needed by asking the patient to hold the railing. The exercise was repeated for ten times

EXERCISE 4

Subject was asked to place one leg forward and shift weight in the forward direction with both the feet firmly placed on the ground. The same procedure was repeated for other leg. The exercise was repeated for ten times

BALANCE TRAINING EXERCISE includes

EXERCISE 1

Mini Hurdle walking

Procedure

On a rough surface placed with stones and small hurdles the subject was asked to walk and cross the hurdles. This was done for 5 minute

EXERCISE2

ZigZag Foot Walk

Procedure

On a straight path, smooth surface hurdles was kept and the subject was asked to move in a zigzag pattern avoiding contact with the hurdles.

EXERCISE3

Cross walking

Procedure

Markings were made on the ground and the subject was made to walk accordingly following the instruction of the therapist.

EXERCISE4

Tandem Walking

Procedure

A straight line was made on the ground and the subject was asked to walk on the straight line placing toe of one leg was touch to heel of another leg.

Duration of all the above mentioned exercise was 15 min

GAIT TRAINING:

EXERCISE 1

Straight Walking

Procedure

A straight line was made on the ground and the subject was asked to walk on the straight line placing toe of one leg was touch to heel of another leg.

EXERCISE2

Side walking

Procedure

Markings are made on the floor and the subjects were made to walk on those markings as instructed by the physiotherapist.

EXERCISE 3

Backward walking

Procedure

Subjects were asked to walk backward for a defined distance.

EXERCISE 4

Walking on foot marks

Procedure

Footmarks were drawn on the floor and the subjects were asked to follow those foot marks as instructed by the physiotherapist.

Duration of all the above mentioned exercise was 15 min

COOL DOWN EXERCISE includes

EXERCISE 1

Slow walking

Procedure

The subjects were asked to walk slowly in an open space

EXERCISE2

Deep breathing exercises

Subjects were made to sit followed by breathing exercise which included deep inhalation a hold time for 3 sec followed by exhalation

This was done for 10 counts

Duration of all the above mentioned exercise was 10 min.

Group 2 (control)

RANGE OF MOTION

Active ROM exercise for all the lower limb joints to be given

ROM procedure

EXERCISE1

Subject was in erect standing and was asked to flex his/her hip at pain free range without bending his/her knee with the subject gaining support through a stationery object. The same was repeated for the other

leg. This was repeated for ten counts for each leg

EXERCISE 2

Subject was asked to hold on a fixed support like a chair or a window bar or railing and then will be asked to take his/her right leg behind i.e. they was asked to take their hip into extension without flexion of knee at a pain free range. The same was repeated for the opposite leg. This was repeated for ten counts

EXERCISE 3

Subject was asked to hold on a fixed support like a chair or a window bar or railing and was asked to take their right leg into abduction and then adduction. The same was repeated for the opposite leg. This was repeated for ten counts

EXERCISE 4

Ask the subject to hold on a fixed support like a chair or a window bar or railing ask him/her to bend his/her right knee first followed by extension at a pain free range. Repeated the same for the opposite leg. This was repeated for ten counts

EXERCISE 5

Subject was asked to hold on a fixed support like a chair or a window bar or railing and they was asked to stand on toes first and then repeated by dorsiflexion of feet. This was repeated for ten counts.

Duration of all the above mentioned exercise was 15 min

GAIT TRAINING:

EXERCISE 1

Straight Walking

Procedure

A straight line was made on the ground and the subject was asked to walk on the straight line placing toe of one leg was touch to heel of another leg.

EXERCISE2

Side walking

Procedure

Markings are made on the floor and the subjects were made to walk on those markings as instructed by the physiotherapist.

EXERCISE 3

Backward walking

Procedure

Subjects were asked to walk backward for a defined distance.

EXERCISE4

Walking on foot marks

Procedure

Footmarks were drawn on the floor and the subjects were asked to follow those foot marks as instructed by the physiotherapist.

Duration of all the above mentioned exercise was 15 min

COOL DOWN EXERCISE includes

EXERCISE 1

Slow walking

Procedure

The subjects were asked to walk slowly in an open space

EXERCISE2

Deep breathing exercises

Subjects were made to sit followed by breathing exercise which included deep inhalation a hold time for 3 sec followed by exhalation

This was done for 10 counts

Duration of all the above mentioned exercise was 10 min.

All the above exercise were followed except strengthening and balancing exercises

Duration of the study:

Nine months including data collection and evaluation.

RESULTS

STATISTICS

Study design: An Experimental study consisting of two groups, each with 50 subjects in Experimental (STRENGTH AND BALANCE TRAINING) and 50 subjects in Control (GENRAL TRAINING EXERCISE) was undertaken to study the efficacy of strength and balance training

exercise for fall prevention in elderly based on FES score and MMT Grade.
Statistical software: The Statistical software namely SPSS 11.0 and Systat 8.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

Statistical Methods: [18-20] Student t test (paired) was used to find the significance of FES and MMT grade between pre-intervention and Post intervention for each group.

1. t-test for two population means (method of paired comparisons)
Objective: To investigate the significance of the difference between two population means. No assumption is made about the population variances

$$t = \frac{(\bar{x}1 - \bar{x}2)}{s/\sqrt{n}}$$

where $s = \sqrt{\sum (di - \bar{d})^2 / n - 1}$

and di is the difference formed for each pair of observations

2. Significant figures
+ Suggestive significance 0.05<P<0.10
* Moderately significant 0.01<P ≤ 0.05
** Strongly significant P≤0.01

Convenient sampling was adopted in the study. A group of 100 patients with fear of fall was selected. They were in the age range of 60-75 years. There were 57male and 43female patients, where 100 subjects are divided into two groups. There were 30 males and 20 females in experimental group with mean age of 70.00 and SD of ±3.17.In the control group there were 27 male and 23 females with the mean age of 70.00and SD of±2.92.

The two groups were compared using FES and MMT.

Pre and post values between the groups was compared using student t- test (two tailed and independent)

Student t-test paired has been used to find the significance of FES and MMT between pre intervention and post intervention for each group.

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. The following assumptions on data is made,

Assumptions: 1. Dependent variables should be normally distributed, 2.Samples drawn from the population should be random, Cases of the samples should be independent Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis) on metric parameters. Leven1s test for homogeneity of variance has been performed to assess the homogeneity of variance. Student t test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale within each group.

Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups, Non-parametric setting for Qualitative data analysis. Fisher Exact test used when cell samples are very small.

TABLE 1

Table 1: Age distribution of patients studied

Age in years	Experimental Group	Control Group	Total
65-70	28(56%)	29(58%)	57(57%)
71-75	22(44%)	21(42%)	43(43%)
Total	50(100%)	50(100%)	100(100%)
Mean ± SD	70.00±3.17	70.00±2.92	70.00±3.03

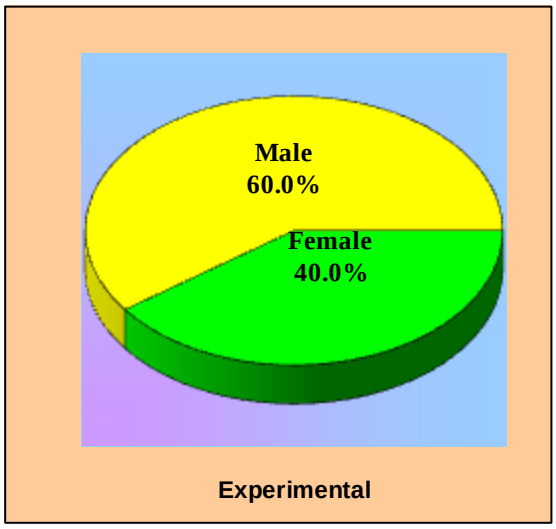
Samples are age matched with P=1.000, student t test

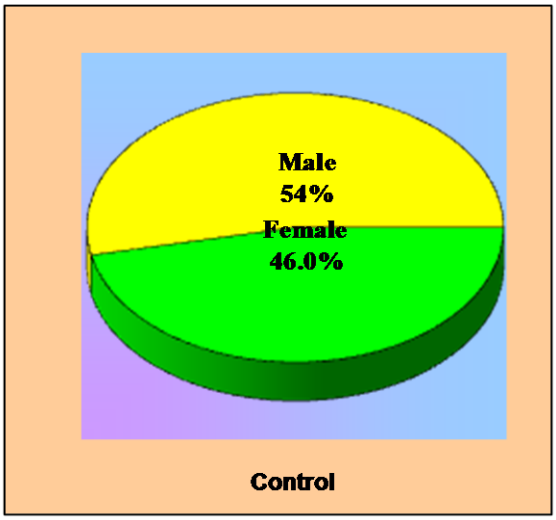
Table2: Gender distribution of patients studied

Gender	Experimental Group	Control Group	Total
Female	20(40%)	23(46%)	43(43%)
Male	30(60%)	27(54%)	57(57%)
Total	50(100%)	50(100%)	100(100%)

Samples are gender matched with P=0.545, chi-Square test

GRAPH 1
GENDER STATISTICS





Graph1 shows the sex distribution illustrating greater percentage of females in both experimental & control groups.

TABLE 3

EFFECT OF STRENGTHENING AND BALNCE EXERCISE IN EXPERIMENTAL AND CONTROL GROUP

Table 3: Fall efficacy scale-A Comparative assessment in two groups of patients studied

Fall efficacy scale	Pre Intervention	Post Intervention	% difference
Experimental Group (n=50)			
• <50	0(0%)	5(10%)	10.0%
• 51-75	19(38%)	45(90%)	
• 75-90	31(62%)	0(0%)	-62.0%
• 91-100	0(0%)	0(0%)	0.0%
Control Group (n=50)			
• <50	0(0%)	0(0%)	0.0%
• 51-75	47(94%)	50(100%)	6.0%
• 75-90	3(6%)	0(0%)	-6.0%
• 91-100	0(0%)	0(0%)	0.0%
P value	<0.001**	0.056+	-

INTERPRETATION: The above result shows that there is improvement in the fall efficacy scale in experimental group and control group when treated with strengthening and balance exercise.

TABLE 4

EFFECT OF STRENGTHENING EXERCISE IN MMT GRADE IN EXPERIMENTAL AND CONTROL GROUP

Table 4: MMT Grade- A Comparative assessment in two groups of patients studied

MMT Grade	Pre Intervention	Post Intervention	% difference
Experimental Group (n=50)			
• 0	0(0%)	0(0%)	0.0%
• 1-2	1(2%)	0(0%)	-2.0%
• 3-6	49(98%)	0(0%)	-98.0%
• 7-9	0(0%)	39(78%)	78.0%
• >10	0(0%)	11(22%)	22.0%
Control Group (n=50)			
• 0	0(0%)	0(0%)	0.0%
• 1-2	0(0%)	0(0%)	0.0%
• 3-6	50(100%)	27(54%)	-46.0%
• 7-9	0(0%)	23(46%)	46.0%
• >10	0(0%)	0(0%)	0.0%
P value	1.000	<0.001**	-

Chi-Square/Fisher Exact Test

INTERPRETATION: The above result shows there is improvement in MMT Grade in the experimental group and control group when treated with strengthening exercise

TABLE5

COMPARISON OF FES AND MMT Grade IN EXPERIMENATL GROUP AND CONTROL GROUP

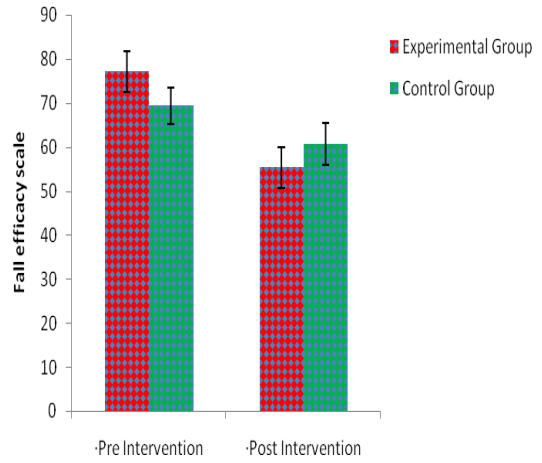
Table 5: Comparison of Full Efficacy scale and MMT score in two groups of patients studied

variables	Experimental Group	Control Group	Total	P value
Fall efficacy scale				
• Pre Intervention	77.10±4.66	69.40±4.09	73.25±5.83	<0.001**
• Post Intervention	55.32±4.60	60.74±4.81	58.03±5.42	<0.001**
• Difference	21.78	8.66	15.22	-
• P value	<0.001**	<0.001**	<0.001**	-
MMT Grade				
• Pre Intervention	4.68±0.89	4.28±0.76	4.48±0.85	0.017*
• Post Intervention	8.94±0.71	6.44±0.88	7.69±1.49	<0.001**
• Difference	4.26	2.16	3.21	-
• P value	<0.001**	<0.001**	<0.001**	-

Between Group- Student t test (Unpaired); Within group- Student t test (paired)

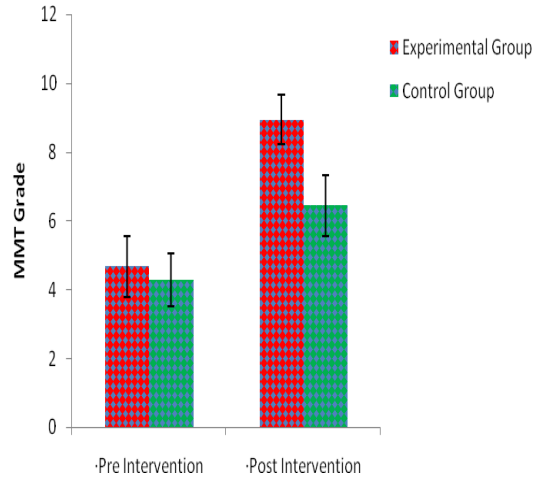
INTERPRETATION: The above table shows that there is significant improvement in FES and MMT Grade in experimental group compared to control group

GRAPH 2a



Graph2a shows significant difference in fes score between experimental and control group

GRAPH 2b



Graph2b shows significant difference in MMT Grade between experimental and control group

DISCUSSION

The aim of the study was to find out the efficacy of strength and balance training exercises for fall prevention in elderly. The result of this study confirmed our hypothesis that strength and balance training exercise reduces the risk and fear of falling

100 subjects were taken and were divided into 2 groups. Both the groups underwent treatment for fall prevention.

FES scale and MMT was used as a main outcome measure. In both the groups there was significant difference in post test score than the pre test scores, but when compared between the groups, experimental group showed significant improvement in function with P value significant at 0.001

There are studies which states that age-related decline in muscular strength is probably the most prominent change that occurs in older adults. Losses in muscular strength occur at an approximate rate of 12-14% per decade after the age 50 years of age [21]

Regular physical activity has been shown to be effective for reducing both chronic disease and disability in older adults. [22] The functional benefits of physical activity for older adults include, but are not limited to: improved cognitive function, cardiovascular health, improved muscle strength and balance, physical functioning, fall reduction and positive contributions to health related quality of life. [23,24] Regular participation in physical activity is key to the maintenance and improvement of independent living in an older adult population. [25] Inactivity has been identified as a major public health concern with the prevalence of disease

increasing with age and activity levels declining with age. [26,27] This is further compounded by the fact that the number of older adults is increasing and the majority of them are not sufficiently active. [28] The economic burden of physical inactivity has been estimated to cost about $2.1 billion dollars annually, which represents 2.5% of the total direct health care costs in Canada. [29] It has also been established that modest reductions in the prevalence of physical inactivity have the potential to reduce health care expenditures by $150 million annually. [29] Therefore, interventions aimed at facilitating the uptake and the improvements of physical activity levels in older adults are important.

Regular physical activity has differential effects on whole-body protein turnover and daily protein requirements. Using measurements of N balance, several studies have now suggested that regular strength training increases the daily requirement for dietary protein. [30]

Some studies also states that strength and mass gains can exceed 30% and 12%, respectively, after two months of resistance training in older men and women. Interestingly, two decades of strength and mass loss can be reversed after engaging in strength training for at least two months. [31] There was a study done by Frontera stating that Resistance training programs for older adults have also been shown to increase muscular hypertrophy (cross-sectional area) and decrease the risk of falling. [32] This study goes in accordance with Baker M that states strength training showed significant improvement in elderly compared to usual activity. [33] This study compared the experimental group who were given strength and balance training exercises with control groups who received general exercise. This study also goes in accordance with hypothesis stated by Skelton D that fear of falling is due to low strength in elderly and tailored strength training exercises are beneficial and reduce the risk of fear of falling. [34] Strength training in the elderly (>60 years) increases muscle strength by increasing muscle mass, and by improving the recruitment of motor units, and increasing their firing rate. Muscle mass can be increased through training at an intensity corresponding to 60% to 85% of the individual maximum voluntary strength. [35] Strength training exercise increase the performance in daily activities of elderly thereby also it reduces the risk and fear of falling and increases the overall self confidence of the individual. This study shows that strength and balance training exercises improves fall prevention and fear of in elderly which is one of the barrier faced by the geriatric population during their functional activities.

CONCLUSION

The study showed that the strength and balance training exercises produces improvements in patients with fear of fall and contributes to significant variations in the outcome measures of the patients and hence the conclusion of the study is that there is a positive and large effect of strength and balance training exercises in the management of fall prevention and fear of fall in elderly, and that there is a marked difference in improvement in MMT Grade and fear of falling has been reduced in these patients when treated with strength and balance training exercises.

Ethical clearance- Taken from institutional ethical committee.
Source of funding- Self
Conflict of Interest- Nil

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