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Research Article

Randomized Controlled Trial of Core Strength Training in Older Adults: Effects on Functional Mobility

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Abstract: Core strength training is widely used to attain dynamic multi-directional movements. Currently the evidence for the effects of core strength training on functional mobility in elderly is less conclusive. This study assessed the effects of core strength training on functional mobility in community dwelling older adults. We enrolled 48 community dwelling elderly males in the age group of 55–70 years and who had given approval for participation in the study. Subjects in the experimental group (Mean age=65± 2.12) performed core strength training exercises in a 6-week series of approximately 45 minutes exercise session, three times per week. The control group (Mean age = 66 ± 2.17) was without any intervention. However all subjects received an information booklet on management of balance problems. Outcome measures were timed "up & go" test and functional reach test. Paired sample t-test, and t-test for independent groups were used to determine significant differences among groups and between pre-test and post-test periods used to analyze the data ($P\leq0.05$).A significant interaction occurred, with the core strength training group showing faster times in the timed up and go test ($t = 7.3605$)and increase in functional reach ($t = 8.8933$) after 6 weeks. The control group has not showed any significant difference between pre-test and post-test values of both outcome measures. It is suggested that exercises to improve core strength can be safely included to the daily exercise regime for the elderly to improve functional mobility.
Keywords: Core Strength Training, Balance, Older Adults, Functional Mobility

INTRODUCTION

During the past few decades the number and proportion of older adults among the world population apparently increased due to socio-economic developments and better medical services. India is facing an elderly population 'time bomb' according to a United Nations report which revealed its number of old people will triple by 2050. The report, by the United Nations Population Fund, found the number of over-60s will increase from around 100 million today to more than 300 million by 2050 and warned the government to prepare for the additional strain this will put on families and health and welfare services[1].Ageing is associated with physical inactivity, low energy intake and loss of skeletal mass. Progressive deterioration of functional mobility is associated with old age. A primary focus for improvement in health care is on promoting patient safety and avoiding injuries to patients. This becomes especially important for elders, who are at risk for functional decline due to altered mobility levels. As the older adult population increases, there is an acute awareness of the impact of falls and fall-related injuries because of morbidity, rising health care costs, and reduction in the quality of life for the elderly. Poor balance has been associated with increased fall risk and mobility disability among older people[2].Limitations in the ability to shift the center of gravity toward the limits of stability may result in reductions in the activity level of older adults. Balance, poor gait, lower limb muscle weakness, slowed reaction time have been identified as independent risk factors for falls in elderly[3].

The ability to confidently and safely perform routine daily activities requires the older adult to generate appropriate motor strategies to navigate in an environment containing both stationary and moving objects within varying contexts. Balance is also needed while the individual manipulates the environment and the feet are stationary. Activities such as bending or reaching up or to the side require shifting the center of gravity (COG) within the base of support (BOS). Once the COG moves outside the BOS, the limits of stability (LOS) for the currently executed balance strategy are exceeded. An automatic movement strategy is executed to maintain balance by either realigning the COG within the BOS or by evoking a step strategy and establishing a new BOS. If the appropriate movement strategy is not executed, the individual may stumble or fall in an attempt to regain balance[4].With aging, physical changes such as impairment in flexibility, balance impairment and slowing reaction time may occur[5].Low relative skeletal muscle mass in older persons is associated with functional impairment and physical disability[6].Ageing reduces muscle capacity in the core muscles of the body causing a reduction in functional mobility. Research suggests that the decrease is most evident in the back, trunk and proximal muscles of the lower limbs[7].In two robust studies, it was found that older adults are less active than younger adults[8].However with ever-rising costs in rehabilitation, it becomes important to develop exercises to allow individuals to exercise at home. According to researchers, patients performing core strength training are able to be more physically active and experience positive effects over a longer period of time. The awareness about the importance of performing physical activity for older adults has been increasing in our country. A growing body of research shows that muscle strength decreases with increased age and that reduced muscle strength is one of the major risk factors for falling. Exercise interventions aimed at improving muscle strength have been identified as a key strategy for reducing frailty and maintaining function in old age[9].

Age is associated with a 1-2% decline in functional ability per year[10].Having independence in functional mobility tasks significantly reduces the level of long-term care required by an individual with a disability and allows an individual to participate in a range of self-care, productive and leisure activities, thereby promoting a sense of self-worth and actualization[11].The core consists of the abdominal region, hips and back, including the deep muscles along the spine. These muscles work with your legs and arms to move your body in different directions while maintaining control of your position and movement. Core stability is the ability of the lumbo-pelvic hip complex to prevent buckling and to return to equilibrium after perturbation. Although static elements (bone and soft tissue) contribute to some degree, core stability is predominantly maintained by the dynamic function of muscular elements. There is a clear relationship between trunk muscle activity and lower extremity movement[12].Studies show that strengthening core muscles does aid in functional abilities[13].The systemic degeneration of the ageing process is manifested predominantly in the musculoskeletal system as reduced functional mobility. Traditionally, balance and/or lower extremity resistance training were used to mitigate age-related deficits. However, the effects of resistance training are limited and poorly translate into improvements in balance, functional tasks, activities of daily living, and fall rates. Thus, it is necessary to develop and design new intervention programs that are specifically tailored to counteract age-related weaknesses. Recent studies indicate that measures of trunk muscle strength (TMS) are associated with variables of static or dynamic balance, functional performance and falls (i.e., occurrence, fear, rate, and/or risk of falls). Further, there is preliminary evidence in the literature that core strength training (CST) has a positive influence on measures of strength, balance, functional performance, and falls in older adults[14].Less research has been performed on the benefits of core training for elderly. Therefore, in this study the authors wanted to explore whether core strength training could improve functional mobility in older adults. The objective of this study is to determine the effects of core strength training on functional mobility measured by timed up and go test and functional reach test in older adults.

METHODS

We chose a randomised, single-blinded controlled trial, with parallel arms. The study was conducted at A.M. Physiotherapy Centre, Kerala, India. The study was approved by the local ethics committee on 18th March 2014 and all the subjects signed an informed consent form. Subjects were recruited from poster advertising mainly at the state pensioner's association office, referrals from other health professionals and by word of mouth. We recruited 48 community dwelling elderly males in the age group of 55 –70 years. Community dwelling elderly with Body Mass Index (BMI)ranging 20–30 who has the independence to be able to participate in the physical activities were included in the study. Exclusion criteria have been developed to screen out patients with: clinical or musculoskeletal impairments and with any sort of implanted prosthesis of previous fracture in axial skeleton or lower limbs, visual impairments without correction and recent complaints of dizziness or falls. They were excluded if under any sort of regular training in the last 3 months. Subjects who failed to participate for at least three consecutive training sessions were excluded. Subjects were asked not to participate in other physical activities or change their daily habits during the study. They were randomly allocated in the two groups. Intervention group (24 subjects) was submitted to core strength training for 6 weeks; each session being 45 minutes, 3 times a week and the control group was without any intervention.

Outcome Measures:

Functional mobility is the capacity to move from one position to another, to enable participation in normal daily routines and activities. All subjects and controls completed Timed up and go test and Functional Reach Test(described in the following section) at pre-intervention and again at the end of the 6-week intervention period.

1. Timed up and go test (TUG)

TUG is a widely used measure of functional mobility and appears sensitive and specific predictor of fall among community dwelling older adults. The timed

"Up & Go" test measures, in seconds, the time taken by an individual to stand up from a standard arm chair, walk a distance of 3 meters, turn, walk back to the chair, and sit down again.TUG test provides information about transfer, balance and gait speed[15].The TUG test has excellent test-retest reliability (ICC = 0.97) for the community-dwelling elderly people. It also possesses excellent Inter-rater reliability (mean difference between raters = 0.04 seconds) in elderly adults[16]. TUG test procedure is as per reference available in site [36].

2. Functional reach test (FRT)

FRT is meant to determine the distance that a person can move his center of gravity in the anterior direction before needing to take a compensatory step. It assesses a patient's stability by measuring the maximum distance an individual can reach forward while standing in a fixed position. The FRT is an indicator of limits of stability (LOS).The Functional Reach Test (FRT) is an inexpensive and easy to use tool to assess LOS in the forward direction.The FRT measures LOS only in the forward direction. Older adults with balance instability tend to overestimate their forward reach ability. An overestimation of forward reach coupled with reduced postural limits may cause loss of balance in older adults performing activities associated with moving the COG toward the forward LOS[17].The instrument is provided [37].

FRT has excellent test-retest reliability (ICC = 0.89) among community dwelling elderly[18]. Measurements were made before training and after six weeks of training.

Core Strength Training:

The participants of the experimental group were subjected to core strength training. Control group participants did not receive any treatment. However all subjects received an information booklet on management of balance problems. A warming up period before the activity included short walks. They were followed by gentle stretching exercises. The exercise group participated in a steadily progressing supervised core strengthening program. A series of core strength training exercises was safely performed under the supervision of trained physical therapists. Core strength training (CST) involves exercises that are challenging for both trunk muscles and postural control and may thus have the potential to induce benefits in trunk muscle strength, spinal mobility and balance performance. The following core strengthening exercises were performed for 3 sets with 10 repetitions. Supine bent-knee lifts, Quadruped with alternate arm-leg raises, Prone plank, Side plank-left, Side plank-right, Bridging and Bridges with leg lifts. Using Microsoft Excel, data was converted into SPSS (Statistical Package for Social Sciences) format for analysis. SPSS version 19 was used. The descriptive statistics were first calculated and the distribution of data was checked.

RESULTS

The results show that there was statistically significant difference in TUG scores and FRT scores in participants of the experimental group subjected to core strength training. There was no statistically significant difference in both outcome measures among participants of the control group. Statistical analysis was done using independent 't-test' to compare the descriptive characteristics (age, height, weight) and no statistically significant difference was found. The significance level was set at 0.05. The results of unpaired 't-test' with mean showed the homogeneity of two groups (Table-1).The pre-test TUG scores of the control group and the core strength training group were compared using unpaired 't- test' (time in seconds). By conventional criteria, this difference is considered to be not statistically significant (p= 0.6709; t = 0.4276) (Table-2). The pre-test and post-test TUG scores of control group were compared using paired 't- test' (time in seconds).By conventional criteria, this difference is considered to be not statistically significant (t = 0.1548; P= 0.8783) (Table-3). The pre-test and post-test TUG scores of core strength training group were compared using paired 't- test' (time in seconds). By conventional criteria, this difference is considered to be statistically significant (t = 7.3605) (Table-4).

The pretest FRT values of control group and core strength training group has been compared using unpaired t test (distance in cm). By conventional criteria, this difference is considered to be not statistically significant (P= 0.4993; t= 0.6810) (Table-5). The pretest and post test FRT values of core strength training group has been compared using paired t test (distance in cm). By conventional criteria, this difference is considered to be statistically significant (Table-6).

Table 1: Comparison of baseline characteristics of the subjects proving homogeneity of two groups.

Variable	Core Training Group	Control Group
Age	65 ± 2.12	66 ± 2.17
Height	166.11 ± 8.43	168.21 ± 8.64
Weight	73.21 ± 4.41	74.07 ± 3.49

Table 2: The pretest TUG scores of control group and core strength training group has been compared using unpaired t test.

Pre test Control (Mean)	Pretest core strength (Mean)	P value	t
8.025 ± 0.730	8.113 ± 0.687	P = 0.6709	t = 0.4276

Table 3: The pretest and post test TUG scores of control group has been compared using paired t test.

Pre test (Mean)	Post test (Mean)	t	P value
8.025 ± 0.730	7.996± 0.788	t = 0.1548	P = 0.8783

Table 4: The pretest and posttest TUG scores of core strength training group has been compared using paired t test.

Pre test (Mean)	Post test (Mean)	t	P value
8.113 ± 0.687	7.300 ± 0.526	t = 7.3605	P value is less than 0.0001

Table 5: The pretest FRT scores of control group and core strength training group has been compared using unpaired t test (distance in cm).

Pre test Control (Mean)	Pretest core strength (Mean)	P value	t
18.000 ± 1.636	18.325 ± 1.670	0.4993	t = 0.6810

Table -6: The pretest and post-test FRT scores of core strength training group has been compared using paired t test (distance in cm).

Pre test Core strength group Mean	Post Test Core strength group Mean	t	P value
18.325 ± 1.670	19.058 ± 1.749	t = 8.8933	P value is less than 0.0001

DISCUSSION

Older adults experience a significant decline in overall functional capacity. A reduction in ability to maintain balance may be associated with an increased risk of falling. It is well documented that strength training can enhance musculoskeletal fitness regardless of age or gender, and increase overall quality of life[19].The participation in physical activities improves reaction time in the elderly. There is an increasing body of evidence suggesting that exercise, as opposed to usual activity, produces positive effects on balance in older people[20].

The purpose of the current study was to determine the effects of a 6 week core strength training program in improving functional mobility in a group of older adults. Our findings demonstrate improvements in functional mobility assessed using TUG test and FRT. Zak et al suggested that the loss of muscle strength and function observed with advancing age is reversible even in the frail elderly[21].Sixty percent of the mass of our body is in the trunk. We need to control this to optimize lower extremity and upper extremity function. Even though muscles have anatomical individuality they do not function that way. All movements of the extremities either originate or are coupled through the trunk[22].During any activity in the limbs, core muscles are active before the prime movers of the limbs. The structure of the spine is more unstable than those of other bones, the roles of the deep muscles are particularly important for spinal stabilization. In particular, through EMG measurement, Hodges and Richardson proved that Transversus Abdominis(Tr A) contracts before any limb movement[23]. The core allows for an improved force output when adequate strength is attained. The trunk connects movements of the lower body to the upper body and vice versa. Force vectors are continuously being transmitted up and down the body when performing movements. Ground reaction forces as well as those generated by the lower body muscles are transferred up the body to the upper extremities when used in an activity[24].In addition, the weight and forces applied at the upper extremities move through the body down to the ground. In either case, the forces all must traverse through the core. The core musculature is also responsible for generating a variety of movements of the trunk in many planes of motion. Activation of Tr Aoccurs approximately 100 milliseconds before leg movement. Tr A contributes to a general mechanism of trunk stabilization before any activity in the limbs and affords greater leverage for upper and lower extremity motions. The loss in reflex ability as well as muscle strength in the rectus abdominis, Transver susabdominis, and external oblique muscles reduces functional ADL for people over 60 years of age[25].A study by Konin reported that the transverse abdominis muscle is the first and main contractor among the core muscles during movements, and it has also been reported that the external oblique muscle is the main factor responsible for maintaining stability, by fixation of the pelvis[26].Paraspinal muscles assist the multifidus muscle to maintain the spine in diverse curvature alignments created by the abdominal muscles[27]. In addition, the thoracolumbar fascia which is connected to the arms and legs is believed to activate proprioception. Through this connection, it is possible that synergic activation would occur. Besides, to maintain balance, synergistic muscles have been reported to provide agonist muscle groups with inhibitory and facilitatory inputs[28].

Core stability is the ability of the lumbopelvic hip complex to prevent buckling and to return to equilibrium after perturbation. Although static elements (bone and soft tissue) contribute to some degree, core stability is predominantly maintained by the dynamic function of muscular elements. The results of our study are in accord with a recent study from Korea by Kim et al which demonstrated improved dynamic balance after performing a lumbar stabilization exercise program[29]. Another study on the effects of a program for trunk strength and stability on pain, low back and pelvis kinematics, and body balance also showed similar results[30].Good core strength prevents abnormal lumbar spine motions associated with leg motion. These factors might have helped in faster time in performing TUG among participants of the experimental group.

Core provides maximal force at the distal end providing precision and stability to the extremities[31].Activation of the deep intrinsic spinal musculature enhances the sensory input to CNS. This increased neuromuscular control of the core enhances the dynamic stability and reduces the exposure of joint surfaces to unusual forces. Fibers of multifidus control inter-vertebral motion and spine orientation. Muscle control depends on input from length and tension receptors in muscles as well as other proprioceptors in and around spinal joints. A higher-order integration of proprioception, mostly from mechanoreceptors in the skin, muscles and joints, allows the body to sense the position of its parts in space[32]. These factors contributed to the improvement in functional reach among participants subjected to core strength training.

Core muscle activation patterns also result in increased levels of muscle activation in the extremities, improving their capability to support or move the extremity. Maximum gastrocnemius plantar-flexor power is generated by use of the hip muscles. Twenty-six percent more activation can occur in the ankle as a result of proximal muscle activation[33].The improvement in FRT is due to the increase in the strength of abductors of the hip. The strength of hip abductors functions to stabilize the femur. The muscles of the core create a greater moment of inertia against body perturbation while allowing a stable base for mobility. Core strength training not only works the muscles in the hips, abdomen and back, it also trains them to all work and function together. It builds coordination between these muscles. Core strength training can reduce the risk of falls by challenging the nervous system to maintain balance and movement coordination. In a 2013 mega-analysis published in "Sports Medicine," researchers concluded that core strength training can increase strength by an average of 30 percent and balance and functional performance by 23 percent among seniors[34].Core strength training improves the rotational movements of the spine. In the elderly, the trunk becomes more rigid so that rotational movement of the pelvis is reduced which can lead to pain and discomfort that limits further movement. Recent cross sectional work has demonstrated that trunk muscle attenuation explains a greater proportion of variance in lower extremity physical function than thigh attenuation, highlighting the importance of trunk muscles [35]. This might be another probable reason for the improvement in functional reach test. The abdominal and lumbar paraspinal muscles provide necessary levels of trunk stability for optimal performance of typical activities of daily living.Strong and endurable core muscles stabilize the spine favorably by providing greater passive support with effective mechanical integrity and enhanced neurological recruitment patterns; including timely activation of these muscles when exposed to forces and loads. These factors attribute to the positive effects on gait and balance of participants subjected to core strength training.

This study had no drop outs and the adherence rate to the exercise program was found very high. No adverse events were reported by the participants or the physiotherapists involved in the core strength training during the study period. A similar recent study from Germany reported that core strength training had a high exercise adherence rate of 92 percent.

Our study concluded that core strength training is a feasible exercise program for seniors to improve functional mobility. CST is an effective, low-cost solution to improve health and other factors that affect falling risk among older adults. It is suggested that exercises to improve core strength can be safely included to the daily exercise regime for the elderly.

The limitations of our study stem from the fact that core muscle activation was not measured in this study. Further studies are needed which include larger heterogeneous samples, to explore the influence of these improvements on the number of reported falls. In future, studies should be directed to explore the gender differences among elderly in strategies to keep a stable body posture. However the present study provides groundwork for future study on the topic of core strength training. This type of training may be more beneficial than traditional strength training exercises in maintaining body stability and imitating the dynamic movements.

CONCLUSION

Overall, our results demonstrate that core strength training program improved functional mobility in community dwelling older adults.CST program could be successfully utilized in other senior independent living communities to improve balance and mobility and potentially reduce the risk of falls. Further, core strength training is low-cost and can be safely practiced both indoors and outdoors.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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