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Effect of Dorsiflexor Muscle Strengthening Using Russian Currents on Balance and Function in Elderly

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ABSTRACT
Balance difficulties are one of the major causes of altered mobility and functional decline in the elderly. Over the past 20 years, a considerable amount of research has been conducted to determine the relationship between balance control and motor or sensory system function in order to understand the causes of falling and to create effective strategies to prevent falls in elderly people The present study was done to determine the effectiveness of dorsiflexor muscle strengthening using Russian stimulation to improve balance and function in elderly. Motor component of balance was evaluated using two tests, i.e., mPOMA and Functional reach test whereas sensory component of balance was measured using mCTSIB and reaction time. Functional performance was typically assessed by Functional gait assessment test, functional ability in performing ADL (like bathing, toileting) and IADL (like travelling, shopping) tasks. Results of the study suggested that balance and functional status of the elderly improved significantly after eight weeks of dorsiflexor strengthening using Russian currents.
Key Words: Body balance, Falls, Strengthening, Russian currents, Dorsiflexor muscles, Elderly

INTRODUCTION

Balance difficulties are one of the major causes of altered mobility and functional decline in the elderly. Changes in the musculoskeletal and nervous systems cause an increase in sway and a decreased ability to adequately and quickly correct movements affecting the center of gravity (Overstall 2003). Deficit in balance control is a major cause of injury in elderly which further deteriorates the quality of life of an individual. Declines in self-efficacy, increased susceptibility to falls, and reduced mobility are serious problems facing many older adults (Desai et al. 2010).

Falls and unstable balance rank high among serious clinical problems faced by older adults. Falls and related injuries are attributed as major contributors to immobility and impoverished quality of life in elderly. Unintentional injuries are the fifth leading cause of death in older adults (after cardiovascular disease, cancer, stroke and pulmonary disorders), and falls constitute two-thirds of these deaths (Rubenstein, 2006).

Over the past 20 years, a considerable amount of research has been conducted to determine the relationship between balance control and motor or sensory system function in order to understand the causes of falling and to create effective strategies to prevent falls in elderly people (Silsupadol et al. 2012).

Previous research has identified three postural movement strategies that are typically used by healthy adults for controlling balance: (1) the ankle strategy, in which balance adjustments are made at the ankle joint and the individual sways as an inverted pendulum; (2) the hip strategy, in which adjustments are made predominantly at the hip; and (3) the suspensory strategy, in which the subject flexes at the ankle, knee, and hip to lower the center of gravity toward the base of support (Woollacott and Shumway- Cook, 1990).

Traditionally, the **ankle strategy** and its related muscle synergy were among the first pattern for controlling upright sway to be identified. The ankle strategy restores the COM to a position of stability through body movement centered primarily about the ankle joints (Shummway-cook and Woollacott, 2007). The ankle strategy applies in quiet stance and during small perturbations and predicts that the plantarflexors /dorsiflexors alone act to control the inverted pendulum (Winter, 1995). Use of the ankle strategy requires intact range of motion and strength in the ankles (Shummway-cook and Woollacott, 2007).

Several studies have shown that lower extremity strength is a common factor associated with balance impairment in elderly fallers (Tanti et al. 1986; Era 1988). Tang and Woollacott(1998), observed age related changes in postural responses to a forward slip. It was shown that balance control was reduced in elderly people when compared to young people. They exhibited longer onset latencies to distal muscle responses, disruptions in the temporal organization of postural muscle responses, and longer agonist/antagonist coactivation duration when they were given external threats to balance.

A number of studies have found that a decline in the muscle strength is partially reversible with exercise. However, do these gains in the muscle strength improve functional skills and balance control is not yet clear. In a study done by Judge et al. (1994), it was suggested that resistance training improved strength but failed to increase gait velocity or decrease chair rise time in comparison to the control group. In the second study, resistance training improved single stance time, but not other balance measures (Chandler & Hadley, 1996). However Fiatarone et al. (1994) performed an intervention that focused on strengthening of the leg muscles of frail elderly three times per week for a period of 8 weeks and found significant gain in the muscle strength. They noted that performance on functional measure was also increased. Another study suggested that enhancement of ankle muscle strength leads to improvements in balance recovery to perturbations in the elderly (Jennifer and Woollacott 2005).

Lord et al. (1994) found that ankle dorsiflexion strength was one of three variables that significantly discriminated between older adults who had no falls or one fall and those with a history of multiple falls. Dorsiflexors are particularly weak in fallers, suggesting that they are an important factor contributing to poor balance. Similarly, Wolfson et al. (1995) evaluated falls in nursing home residents with a history of one or more falls in the last year and found that these individuals had less than half the ankle and knee strength of nonfallers and one tenth of the ankle dorsiflexors strength of control subjects. The association between the weak leg muscles and falling has led to a number of studies of strength training to enhance balance in balance-impaired older adults.

In the present study, Russian currents are used to strengthen the dorsiflexors muscle group. Electrical stimulation is used extensively in physical therapy, and “Russian currents” have been advocated for use in increasing muscle force *(*Selkowitz, 1985; Selkowitz, 1989*)*. This form of electrical stimulation seems to us to be the least understood in terms of physiological effects. Russian currents are alternating currents (AC) at a frequency of 2.5 kHz that are burst modulated at a frequency of 50 Hz with a 50% duty cycle. The stimulus is applied for a 10-second “on” period followed by a 50-second “off” or rest period, with a recommended treatment time of 10 minutes per stimulation session *(*Selkowitz, 1985). This stimulation regimen (called the “10/50/10” regimen), applied once daily over a period of weeks, has been claimed to result in force gains. But no study has been found in the literature review where effect of Russian currents has been studied to increase the dorsiflexor muscle force to enhance balance function in elderly. This approach will be highly beneficial to the frail elderly who cannot perform high resistance strength training and other balance training protocols. The present study was done to determine the effectiveness of dorsiflexor muscle strengthening using Russian stimulation to improve balance and function in elderly.

MATERIAL AND METHODS

Participants: The participants of the study were 30 community dwelling elderly people aged 65 years and older selected randomly. The inclusion criteria were; a) Age 65 years and older, b). mPOMA score of 26 or less, c) Patient should not be involved in any type of exercises from the last six months. Individuals with vertigo, history of acute illness, medicational side effects, syncope, any surgery in the lower limb, neurological diagnosis were excluded from the study.

Protocol: Russian electrical stimulation (2.5-kHz sinusoidal alternating current applied at a burst frequency of 50 Hz and a burst duty cycle of 1:1) was applied for a 10-second "on" period followed by a 50-second "off" period using maximum tolerable intensity, with a recommended treatment time of 10 minutes per stimulation session to both the limbs making total treatment time to be 20 minutes. Stimulations were given 5 days a week for a total period of 8 weeks for ankle dorsiflexors on both right and left limb.

Set up: Following skin inspection and cleansing of the leg rubber electrodes were attached with Velcro straps to the area of stimulation. The proximal electrode was placed over the muscle belly of the tibialis anterior, very midline close to the tibia. The distal electrode is also placed close to the tibia, further down the shank. Placement was adjusted to ensure that negligible eversion/inversion ankle moments and minimal activation of the toe extensors were produced during stimulation.

Outcome measures: Pre and post experimental balance and function measurements were taken using the seven clinical tests including Functional reach test, mPOMA, Functional Gait assessment, mCTSIB (Shummway-cook and Woollacott, 2007), ADL, IADL (Multani and Verma 2007), and audiovisual reaction time.

RESULTS

Table 1.1: Pre and post test measurements for FRT and mPOMA

Clinical measure	Pre Test measurements (0 week)		Post Test measurements(8 weeks)		
	Mean	SD	Mean	SD	t-value
Functional reach test (FRT)	10.46	3.1	16.48	2.62	-20.25*
mPOMA	15.43	5.09	32.1	3.73	-27.12*

*P<0.001

Table 1.1 shows pre and post experimental mean values for Functional reach test and mPOMA. The calculated value of t is higher than the critical value of t at p<0.001which suggest that the difference is statically significant and not a chance finding.

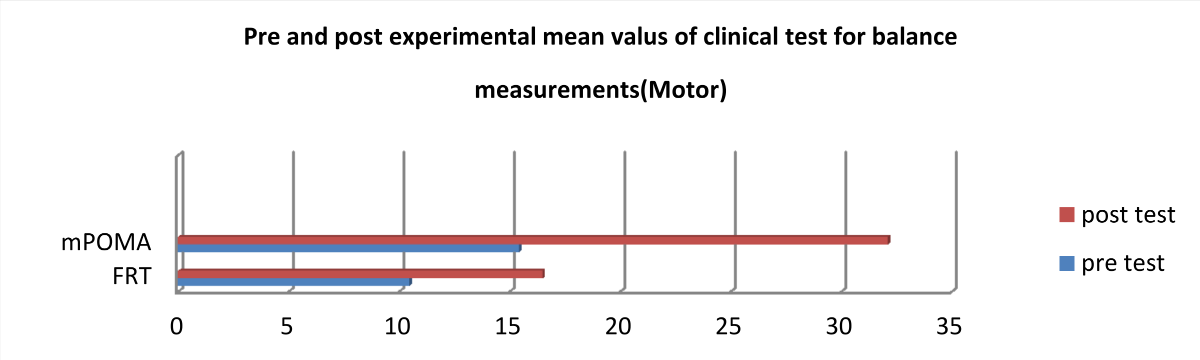

Fig: 1.1 Pre and Post experimental mean values for Forward reach test and mPOMA

Table 1.2 Pre and post test measurements for mCTSIB and Reaction Time

Clinical measure	Pre Test measurements (0 week)		Post Test measurements(8 weeks)		
mCTSIB	Mean	SD	Mean	SD	t-value
Flat Surface Eye open	12.69	5.17	19.92	5.91	-14.71*
Flat Surface eye close	7.44	4.09	13.13	5.71	-7.38*
Foam surface eye open	5.83	3.74	10.21	4.41	-12.26*
Foam Surface eye closed	3.02	2.80	6.83	3.98	-11.70*
Reaction time					
Light	1.82	0.44	1.40	0.43	6.02*
Sound	2.77	0.64	2.13	0.45	10.26*

*P<0.001

Table 1.2 shows the pre and post interventional mean values for the mCTSIB (Flat surface eye open, Flat surface eye close, Foam surface eye open, Foam surface eye close) and reaction time test (Light and Sound). Observed t-values for both the tests were found to be greater than the critical value of t at P<0.001 which suggest that the improvement observed in both the sensory parameters of balance after 8 weeks of intervention is statistically significant .

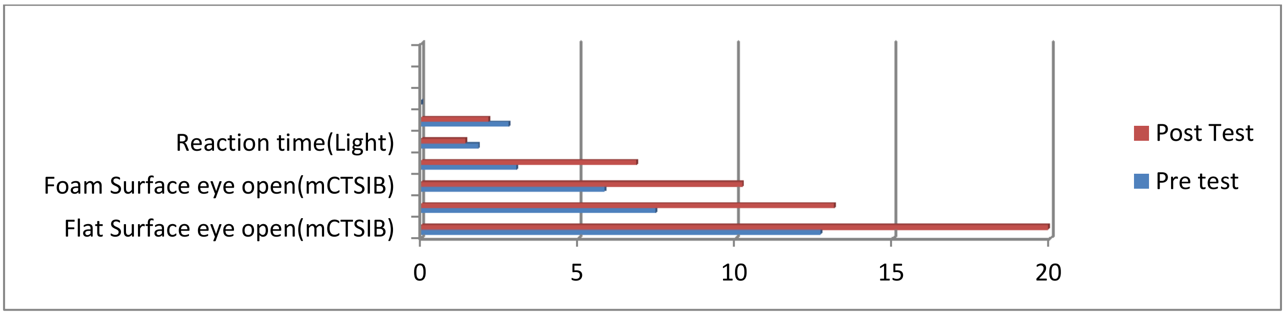

Fig 1.2 Pre and Post experimental mean values for mCTSIB and Reaction time (light and sound)

Table 1.3 Pre and post test measurements for FGA, ADL, IADL

Clinical measure	Pre Test measurements (0 week)		Post Test measurements(8 weeks)		
	Mean	SD	Mean	SD	t-value
Functional Gait Assessment (FGA)	7.76	4.5	16.53	4.16	-18.04*
ADL	10.2	1.97	11.2	1.09	-3.94*
IADL	7.86	2.8	8.43	2.51	-2.81*

*P<0.001

Table 1.3 shows the mean values for functional gait assessment, ADL and IADL. The calculated t-value for all the three tests were observed to be greater than the critical value of t at P<0.001 which suggest that the improvement observed in all the three parameters of function is statistically significant. Thus the intervention is effective in improving the functional status of elderly.

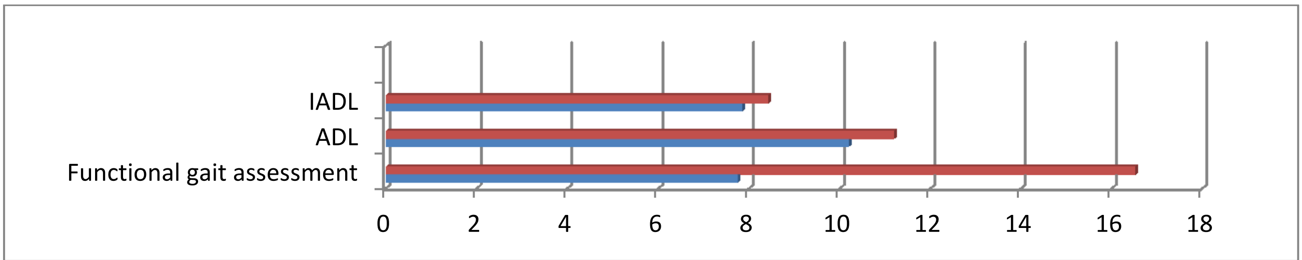

Fig 1.3 Pre and Post experimental mean values for Functional gait assessment, ADL, IADL

DISCUSSION

Results of the study suggested that balance and functional status of the elderly improved significantly after eight weeks of dorsiflexor strengthening using Russian currents. The dorsiflexor group provides two important functions during locomotion. During the swing phase when the foot is off the ground, the dorsiflexor muscles help lift the foot and toes off the ground to provide adequate ground clearance. The second function occurs at and immediately after ground contact when the dorsiflexors oppose the plantar flexion movement imparted to the foot by the ground reaction force and control the descent of the foot on the ground. Therefore, the purpose of giving strength training to ankle dorsiflexors was to obtain an optimum function from them during static and dynamic functional tasks.

Electrical stimulation is used extensively in physical therapy, and “Russian currents” have been advocated for use in increasing muscle force. In the present study, Russian currents stimulation was used to strengthen the dorsiflexor muscle group in elderly as till now no study has identified use of this type of electrical stimulation in relation to improvement of balance and function in elderly and Russian currents are the least understood currents. Further Kots' (1977) argument for the use of electrical stimulation combined with voluntary exercise was that the commonly used exercise programs (those used at the time) build muscle bulk and muscle force but ignore the role of skill and fine motor control. Electrical stimulation, however, preferentially recruits the fast-twitch, fast-fatiguable motor units associated with sudden, rapid movement, precise motor control, and gracefulness of movement. Moreover electrical stimulation will be helpful for strengthening in those elderly who cannot voluntarily perform the exercise due to health problems.

Motor component of balance was evaluated using two tests, i.e. mPOMA and Functional reach test whereas sensory component of balance was measured using mCTSIB and reaction time. Improvement observed was highly significant in all the tests after the training. From the findings it could be suggested that dorsiflexor muscle strength is an important component for maintaining static and dynamic balance. By strengthening the dorsiflexors, ankle strategy can be trained thereby improving postural control and balance. The ankle strategy restores the COM to a position of stability through body movement centered primarily about the ankle joints (Shummway-cook and Woollacott, 2007).

Functional performance was typically assessed by the time required to complete a variety of gait and mobility tasks using Functional gait assessment test , functional ability in performing ADL (like bathing ,toileting) and IADL (like travelling, shopping) tasks. A Statistically significant improvement was observed in all the three tests for functional performance after the training. The focus of the study on utilizing ankle dorsiflexor strength training methods to improve functional ability tasks reflects two factors. These are: 1) the significant role that walking, stair climbing and rising from a chair play in maintaining independence and quality of life in older adults; and 2) how a certain level of muscular power is required for independent performance of these ADL and IADL tasks. The result suggested that ankle dorsiflexor strength is an important component for maintaining balance and performing various functional tasks independently.

CONCLUSION

Strengthening of the dorsiflexor group of muscle significantly improved the balance (motor and sensory components) and function in elderly therefore ankle dorsiflexor strength can be considered as an important component for maintaining balance and independent functioning in elderly. So it could be concluded that strengthening of dorsiflexor muscle group should be included as a major component in balance training protocols.

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