Balance Performance and Ankle Dorsiflexors Muscles Force in Elderly: A corelational study

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ABSTRACT

BACKGROUND: Balance and muscle force deteriorate with aging. It has been suggested that a decrease in the ability to generate force in the lower extremity muscles contribute to balance impairment and falling. This study investigated the effects of the both resisted exercises and electrical stimulation for ankle dorsiflexors muscles force and their relation to balance control in elderly subjects.
SUBJECTS AND METHODS: Fifty healthy elderly subjects, their age ranged 65-75 years, participated in this study. Twenty five subjects (training group) were trained with resisted exercises plus electrical nerve stimulation of ankle dorsiflexors muscles, three times a week for 8 weeks. The control group, included twenty five subjects, received no treatment intervention except encouragement for performing their usual activity of daily living over the 8 weeks of the study. The ankle dorsiflexors muscles force was measured by the hand held dynamometer in Kg and the balance control was measured by the Berg Balance Scale (BBS), the Functional Reach Test (FRT) and the Timed Get Up-Go Test (GUG). These measurements wevr5re applied for both groups before and after 8 weeks.
RESULTS: The BBS, FRT and GUG values showed significant changes (12.9%, 35.7% and 51.9% respectively) following training in the trained group. There were no significant changes (0.67%, 6.95% and 14.4%) in the same measures of the control group after 8 weeks.
***Key words:** Balance, Ankle Dorsiflexors Muscles Force, Resisted Exercises, Electrical Nerve Stimulation and Elderly.*

INTRODUCTION

An estimated 25% to 35% of adults aged 65 years and older fall each year. The high fall incidence in older adults is costly in terms of both health care dollars and quality of life. Most older adults hospitalized for falls are discharged to long term care facilities. Cessation of physical activities, whether due to fear of falling or due to declining mobility and balance ,accelerates the decline in muscle force production and function, further increasing fall risk and further decreasing quality of life[2,7,10,11].

Risk factors for falls among elderly people include environmental hazards and housing characteristics, and deterioration of the neuromuscular system. Individual factors related to increased risk of falling include being female, older age, medication use (particularly sedative or multiple drug use), co morbidities (e.g. stroke or arthritis), physical and mobility limitations, limited vision, dizziness and cognitive impairments[8].

Postural control is complex and no single comprehensive measure is available that tests all aspects of the postural control system. The ability to maintain control of posture is critical for the successful performance of most daily activities. Postural control is defined as the maintenance of body's center of gravity within its base of support during stance or voluntary movements[1].

The three commonly used methods for measurement of balance are the Berg Balance Scale (BBS), the Functional Reach Test (FRT) and the Timed Get Up-Go Test (GUG)[3,9].

The BBS was developed to measure balance impairments in elderly people and those with neurological disorders. The FRT was designed to test the ability to control movement of the center of gravity over a fixed base of support and to measure the limits of stability in the anterior direction. The GUG was designed as a quick measure of basic balance skill in elderly people. It measures the ability to adjust the center of gravity continuously over a moving base of support[16,20].

The purpose of this study is to determine the effect of electrical stimulation and resisted exercise training program on ankle dorsiflexors muscles force and balance performance in elderly subjects.

SUBJECTS AND METHODS

Subjects

Fifty healthy elderly subjects of both sexes (25 males and 25 females) , with age ranged from 65 to 75 years .None of the subjects had significant co morbid disease that would interfere with balance. The participants signed a consent form and were informed they could withdraw from the study at any time.

Measurements

A systematic approach to assessment of ankle dorsiflexors muscles force and balance uses a variety of tests and measurements to document functional abilities as following

1- Balance performance measurements

The three balance measures were the BBS, FRT and GUG. The BBS consists of 14 tasks which are: (1) sit to stand, (2) standing unsupported, (3) sitting on stool, (4) stand to sit, (5) transfers, (6) standing with eyes closed, (7) standing with feet together, (8) reaching forward with an outstretched arm, (9) retrieving an object from the floor, (10) turning the trunk with feet fixed, (11) turning 360 degrees, (12) stool stepping, (13) tandem standing and (14) standing on one limb. These are scored from 0 to 4, where 0 indicates an inability to perform the task and 4 indicates the task was performed correctly and independently. The maximal possible score on this test is 56. The FRT was measured as the maximal distance that subjects could reach forward horizontally beyond arm's length while maintaining a fixed base of support in the standing position. The distance was measured (in centimeters) on a tape measure fixed to a wall. The G U G, measures the time in seconds taken for subjects to rise from an armchair, walk 3 meters, turn and return to the chair[9].

2- Ankle dorsiflexion muscles force

Hand held dynamometer (Penny and Giles, Biometrics Division, Blackwood Gwent NP2 IYD United Kingdom) was used for measuring ankle dorsiflexion muscles force. A stabilization frame was designed and manufactured, this frame was used for testing ankle dorsiflexion muscle force with the subject in a long sitting position with the hip flexed between 70 and 80 degrees and the knee extended. The end piece of the dynamometer was applied to the dorsal surface of the foot, proximal to the metatarsophalangeal joints, for measurement of dorsiflexors muscle force. The ankle dorsiflexion muscles force was tested in mid range of the ankle joint and the subject asked to exert maximum force during the test. The mean of the three measurements was used for data analysis. Each trial lasted 4 to 5 seconds so, the subjects could be instructed to increase their force to maximum over a few seconds[4].

Procedures

Subjects were assigned randomly to one of two groups:

Group (1) (Training group): Twenty Five healthy elderly individuals with mean age (68.2 ± 2.35 years) received:

a) Neuromuscular Electrical Stimulation program: Self adhesive electrodes were placed over common perneal nerve near to the head of the fibula and over a motor point in the tibialis anterior muscle. The skin was marked with a permanent marker to standardize electrode placement across sessions. A sine wave with 2500 HZ carrier frequency was delivered in 80 bursts per second. The bursts frequency was reported to be most comfortable by the subject. The current was adjusted to the highest level tolerated by each participant during each session, which lasted for twenty minutes.

b) Resisted Exercise Training for ankle dorsiflexion muscles: Each patient received an individualized exercise program addressing the specific impairments and functional disabilities identified during the assessment. During exercise training, patients positioned in supine lying position, and resistance was applied to the dorsum of the foot just above the toes to resist dorsiflexion while stabilization was applied to the lower leg. The amount of resistance increased gradually to be suitable to the subjects tolerance. Each subject rested for 30 seconds after each contraction to avoid fatigue. Duration of exercise training was twenty minutes. The patients of the trained group received three sessions per week for 8 weeks.

Group (2) (control group): Twenty Five healthy elderly individuals their mean age 69.1 ± 2.46 years were considered as the control group and received no therapeutic intervention.

In both groups, the measures of balance (BBS, FRT and GUG) and ankle dorsiflexion muscles force was done before starting of the study and repeated after 8 weeks at the end of the study.

Statistical analysis

The mean values of BBS, FRT, GUG and ankle dorsiflexion muscles force, obtained before and after 8 weeks, of both experimental and control groups were compared by using the paired ″t″ test and the independent ″t″ test was used for the comparison between the two groups ($P<0.05$). Pearson’s product moment correlation coefficients (r) were applied to examine the degree of correlation among ankle dorsiflexion muscle force, BBS, FRT and GUG.

RESULTS

Data collected from the training group indicated that

- The pre test value of BBS showed a mean 48.13±1.30 which was changed to54.40±1.68 after treatment intervention .The difference between the pre and post test values showed a significant difference.
- The pre test value of FRT showed a mean 38.40±1.84 cm which was changed to 46.53±2.06 cm after treatment intervention. The difference between the

pre and post test values showed a significant difference.

- The pre test value of GUG showed a mean 14.47±1.19 sec. which was changed to9.20±1.21 sec. after treatment intervention .The difference between the pre and post test values showed a significant difference.
- The pre test value of Ankle Dorsiflexion Muscle Force showed a mean 12.33±1.9 kg which was changed to18.73±1.67 kg after treatment intervention. The difference between the pre and post test values showed a significant difference.

Table (1): Shows the difference between the pre and post values of BBS, FRT, GUG and ankle dorsiflexion muscles force of the training group.

	Mean ± SD		t-value	Significance
	Pre	**Post**		
BBS	48.13 ± 1.30	54.40 ± 1.68	8.78	Significance
FRT (cm)	38.40 ± 1.84	46.53 ± 2.06	8.21	Significance
GUG (sec)	14.47 ± 1.19	9.20 ± 1.21	-7.48	Significance
Ankle Dorsiflexion Muscle Force (Kg)	12.33 ± 1.9	18.73 ± 1.67	8.69	Significance

BBS: Berg Balance Scale. FRT: Functional Reach Test. GUG: Timed Get Up Go Test.
SD: Stander Deviation. cm: centimeter. sec: second Kg: Kilogram

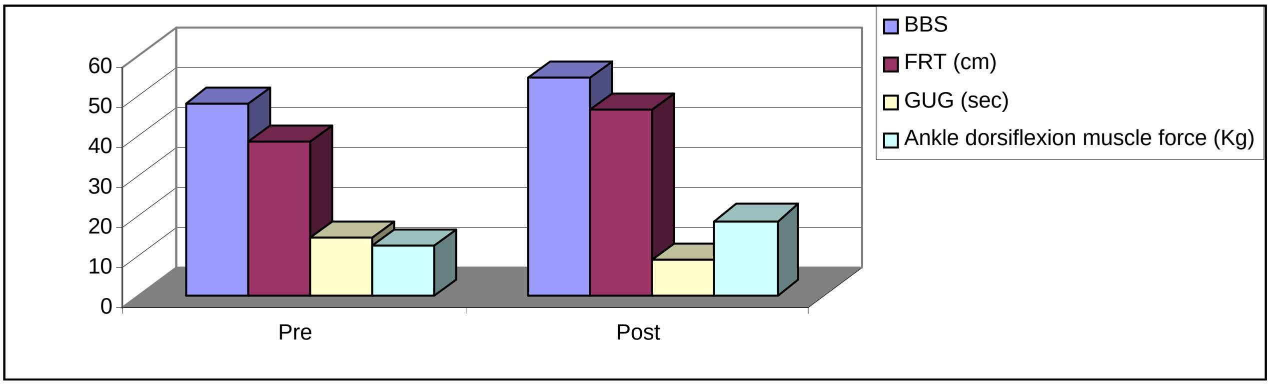

Fig. (1): Shows the difference between the pre and post values of BBS, FRT, GUG and ankle dorsiflexion muscles force of the training group.

Data collected from the control group indicated that

- The pre test value of BBS showed a mean 47.20±1.47which was changed to48.60±1.72after treatment intervention. The difference between the pre and post test values showed no significant difference.
- The pre test value of FRT showed a mean 37.40±2.56 cm which was changed to 40.0±3.48 cm after treatment intervention .The difference between the pre and post test values showed no significant difference.
- The pre test value of GUG showed a mean 14.87±1.60 sec. which was changed to12.73±2.12 sec. after treatment

intervention. The difference between the pre and post test values showed no significant difference.

- The pre test value of Ankle Dorsiflexion Muscle Force showed a mean 11.67±1.39 kg which was changed to13.13±1.64 kg after treatment intervention. The difference between the pre and post test values showed no significant difference.

Table (2): Shows the difference between the pre and post values of BBS, FRT, GUG and ankle dorsiflexion muscles force of the control group.

	Mean ± SD		t-value	Significance
	Pre	**Post**		
BBS	47.20 ± 1.47	48.60 ± 1.72	1.69	Non Sig.
FRT (cm)	37.40 ± 2.56	40.00 ± 3.48	1.55	Non Sig.
GUG (sec)	14.87 ± 1.60	12.73 ± 2.12	-1.80	Non Sig.
Ankle Dorsiflexion Muscle Force (Kg)	11.67 ± 1.39	13.13 ± 1.64	1.97	Non Sig.

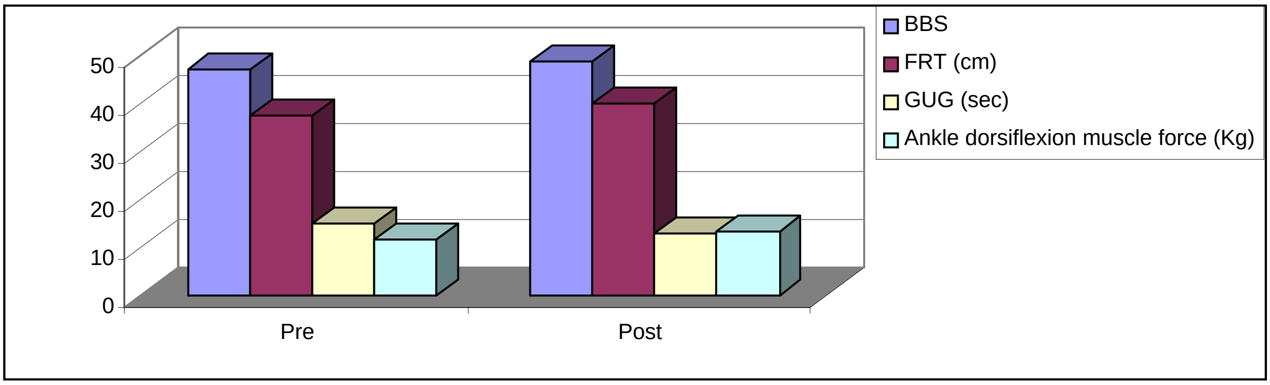

Fig. (2): Shows the difference between the pre and post values of BBS, FRT, GUG and ankle dorsiflexion muscles force of the control group.

Data collected in the training and the control groups indicated that

- The mean of the difference of BBS were54.4 ±1.68 after treatment intervention in the training group and 48.60 ±1.72 at the end of the study in the control group. The difference between the training group and the control group showed a significant difference.
- The mean of the difference of FRT were 46.53 ±2.06 cm after treatment intervention in the training group and 40.0±3.48 cm at the end of the study in the control group. The difference between the training group and the control group showed a significant difference.
- The mean of the difference of G U G were 9.20 ±1.21 sec. after treatment intervention in the training group and 12.73 ±2.12 sec. at the end of the study in the control group .The difference between the training group and the control group showed a significant difference.
- The mean of the difference of Ankle Dorsiflexion Muscle Force were 18.73 ±1.76 kg after treatment intervention in the

training group and 13.13 ±1.64 kg at the end of the study in the control group. The difference between the training group and the control group showed a significant difference.

Table (3): Shows the difference between the effect of both groups on BBS, FRT, GUG, and ankle dorsiflexion muscles force after 8 weeks.

	Mean ± SD		t-value	Significance
	Training	**control**		
BBS	54.40 ± 1.68	48.60 ± 1.72	6.59	Sig.
FRT (cm)	46.53 ± 2.06	40.00 ± 3.48	4.59	Sig.
GUG (sec)	9.20 ± 1.21	12.73 ± 2.12	-4.11	Sig.
Ankle Dorsiflexion Muscle Force (Kg)	18.73 ± 1.76	13.13 ± 1.64	6.55	Sig.

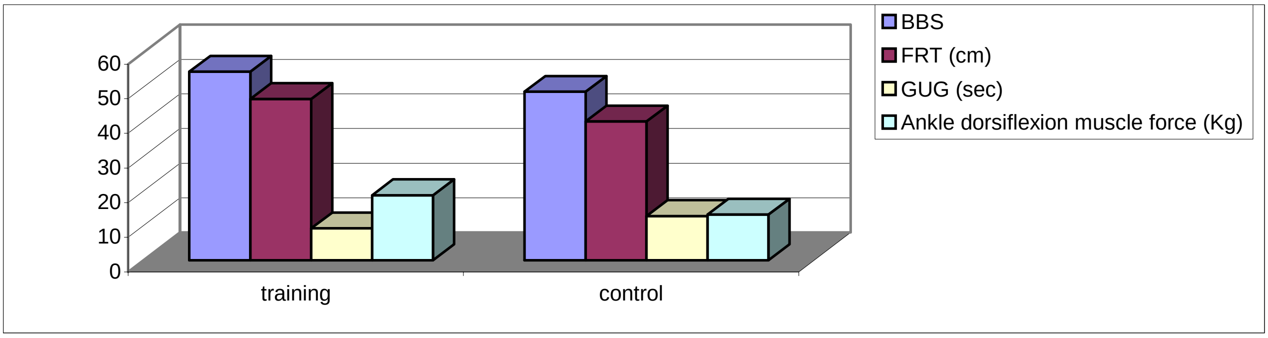

Fig. (3): Shows the difference between the effect of both groups on BBS, FRT, GUG, and ankle dorsiflexion muscles force after 8 weeks.

The Pearson's correlation coefficients test for the relationship between the grade of BBS, FRT, GUG and ankle dorsiflexion muscle force in the training group showed a strong direct relationship.

Table (4): Shows the Pearson's correlation coefficients test value and the relationship between the grade of BBS, FRT, GUG and ankle dorsiflexion muscle force in the training group.

Test	Pearson's value	Relationship to ankle dorsiflexion muscle force
BBS	0.94	Strong direct relationship
FRT	0.95	Strong direct relationship
GUG	-0.88	Strong inverse relationship

The Pearson's correlation coefficients test for the relationship between the grade of BBS, FRT, GUG and ankle dorsiflexion muscle force in the control group showed a strong direct relationship.

Table (5): Shows the Pearson's correlation coefficients test value and the relationship between the grade of BBS, FRT, GUG and ankle dorsiflexion muscle force in the control group.

Test	Pearson's value	Relationship to ankle dorsiflexion muscle force
BBS	0.95	Strong direct relationship
FRT	0.96	Strong direct relationship
GUG	-0.89	Strong inverse relationship

DISCUSSION

This study was designed to examine the extent to which the force of ankle dorsiflexors affect the measures of balance. Fifty elderly subjects were involved in this study, divided into two equal groups. The training group received Neuromuscular Electrical Stimulation and Resisted Exercise Training for the ankle dorsiflexion, while the control group received no specific training. The measures used in this study were balance measures (BBS, FRT, and GUG) and ankle dorsiflexion muscles force. Measurements were taken before the treatment program (pretest) and at the end of the program (post test) after 8 weeks.

Regarding the changes that occurred in BBS, FRT and ankle dorsiflexion muscles force between the first and final evaluations in the training group, the results showed that there was a significant increase. While the results of GUG showed a significant decrease. The results of the control group showed no significant change between the pre and post values of either BBS, FRT, GUG or ankle dorsiflexion force.

There was a significant difference between both groups regarding BBS, FRT, GUG and ankle dorsiflexion muscles force in the final evaluation of the experimental and the control groups.

In the training group and the control group their was a strong direct relationship between the values of BBS and FRT and the ankle dorsiflexion force values respectively. Also there was a strong inverse relationship between the ankle dorsiflexion force and the GUG values after 8 weeks. These results reflect the relationship between the ankle dorsiflexion muscle force and the balance performance.

The selection of ankle dorsiflexors in this study depends on the results of the previous studies in this field which indicated that ankle dorsiflexors force was a predictor of balance and fall status. Balance and muscle force deteriorate with aging, it has been suggested that a decrease in the ability to generate force in the lower extremity muscles contributes to balance impairment and falling[6,18].

The results of this study indicated that resisted exercise training and neuromuscular electrical stimulation resulted in improvement of ankle dorsiflexors strength and balance measures among elderly subjects and there was a strong direct correlation between improvement of ankle dorsiflexors muscle strength and balance tests. The improvement of the total scores BBS test after 8 weeks of training indicated more control of the body segments, posture and muscles during performing the activities of daily living. Increasing the FRT scores and decreasing the time measured in GUG test reflected increase in muscle force, joints flexibility, balance control as well as self confidence and psychological well being.

The results were consistent with the recently published studies which demonstrated that exercise can help to improve balance, reduce falls or fall risk and ability to transfer safely in community- dwelling older adults[5,14,17,18]. It was reported an improvement in balance following high intensity strength training in older adults after a 6 weeks program of aerobic walking improved balance among older adults, but changes in falls were not reported[13,15]. Also, it was reported improvements in static balance in women over the age of 60 years[4], but not in men after 3 months of strength and flexibility training. Also, exercise training in older adults resulted in decrease in stance postural sway and the exercise group had fewer falls during their experimental tests of balance compared with subjects who did not exercise[19].

The mechanisms for the increased force generating ability following training with electrical stimulation are still unknown. During volitional activation, type I fibers are believed to be recruited first due to small diameter neuron depolarization . Depending on the intensity and duration of the effect and the fatigue level occurring, type II fibers are then recruited according to the size principle. There has been a suggestion that electrical stimulation results in a reversed recruitment order of motor units with earlier and selective activation of type II as decreased force production in elderly is related to decreased muscle mass, decreased muscle fiber number and size (particularly type II fiber atrophy)[12].

CONCLUSION

The results of this study indicated that both resisted exercise and electrical nerve stimulation were viable methods of strength and balance augmentation in elderly people. Dependency on active life style for improving strength and balance was not enough.

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الملخص العربي

الاتزان و قوة عضلات شد الكاحل للأمام لدى المسنين: دراسة ارتباطيه

لقد أصبح تأثير التمرينات على المسنين بؤرة الاهتمام في معظم الأبحاث الحديثة . وقد تتأثر قوة العضلة والاتزان بالسن . وأتضح وجود علاقة بين قوة عضلات الأطراف السفلي وتدهور الاتزان والسقوط . وتبحث هذه الدراسة محصلة التأثير لكل من التدريبات ذات المقاومة والتنبيه العضلي لعضلات شد الكاحل للأمام على قوة العضلة والتحكم في الاتزان لدى المسنين . وقد أجريت هذه الدراسة على خمسون مسن من الأصحاء ، تراوحت أعمارهم : 65- 75 سنة. قسموا عشوائيا إلى مجموعتين متساويتين . تلقت المجموعة الأولى برنامج علاجي لتقوية عضلات شد الكاحل للأمام ثلاث جلسات أسبوعيا لمدة شهرين. أما المجموعة الثانية "الضابطة" فلم تزاول سوى النشاط اليومي المعتاد لها . وقد أوضحت النتائج وجود زيادة ذات دلالة إحصائية ملحوظة في قياسات الاتزان بالنسبة للمجموعة الأولى ، بينما المجموعة الثانية أظهرت تحسن طفيف جدا . وتؤكد نتائج هذا البحث أن اعتماد المسن على النشاط اليومي فقط ليس كافيا للحفاظ على أو تحسين الاتزان والقوة وتفادى السقوط ، مما يظهر أهمية استخدام التمرينات العلاجية أو التنبيه الكهربي لتقوية عضلات الأطراف السفلي والحفاظ على الاتزان .