Effect of Lower Extremity Stretching Exercises on Balance in Geriatric Population

Ravi Shankar Reddy, PhD, PT; Khalid A Alahmari, PhD, PT

Department of Medical Rehabilitation Sciences
College of Applied Medical Sciences, King Khalid University, Abha, KSA

Abstract

Background and Objective: The purpose of this study was to find "Effect of lower extremity stretching exercises on balance in the geriatric population.

Method: 60 subjects (30 male and 30 female) participated in the study. The subjects underwent 10 weeks of lower limb stretching exercise program. Pre and post 10 weeks stretching exercise program, the subjects were assessed for balance, using single limb stance time in seconds and berg balance score. These outcome measures were analyzed.

Results: Pre and post lower extremity stretching on balance was analyzed using paired t test. Of 60 subjects 50 subjects completed the stretching exercise program. Paired sample t test analysis showed a significant improvement in single limb stance time (eyes open and eyes closed) ($p<0.001$) and berg balance score ($p<0.001$).

Conclusion: Lower extremity stretching exercises enhances balance in the geriatric population and thereby reduction in the number of falls.

Key words: stretching; Balance; Berg Balance Score; single limb stance time

Corresponding Author:

Dr. Ravi Shankar Reddy. PhD, PT
Assistant Professor, Program of Physical Therapy
Department of Medical Rehabilitation Sciences
College of Applied Medical Sciences
King Khalid University,
P. O. Box number - 3665
Guraiger, Abha - Kingdom of Saudi Arabia
Ph: +966 503587903

Introduction

Falls are among the leading causes of fatal and nonfatal injuries in the elderly. [1] A lot of revenue is spent annually for the care of the elderly with fall-related Injuries. [2] Falls increase with age. [2] In 2001, adults older than 85 years were 4 to 5 times more likely to suffer a fall-related injury than adults aged between 65 and 74 years. [1-3] The prevention of falls and the substantial morbidity associated with fall-related injuries will become increasingly important for preserving the health and independence of the older population. [4] Fall risk has been shown to increase with reduced lower extremity flexibility. [4]

Balance is the ability to maintain the body's centre of mass (COM) within the limits of the base of support. [5] Depending on the motor task people use 3 different strategies to maintain their upright posture. These are known as ankle, hip, and step strategies. Both hip and ankle strategies involve activation of the hip and ankle muscles opposite to the direction of the perturbation. [5] When the amplitude of the perturbation is too large, the step strategy is utilized. The step strategy is performed by taking a step in the direction of the perturbation, although the base of support is realigned under the COM. This allows maintenance of the COM within the base of support preventing external forces to disturb balance and thus maintain upright posture. [2, 3, 5]

Examination of flexibility activities for older adults is common and it has been stated that as an effect in decreased joint range of motion which is associated with aging. [6, 7] While systematic reviews have concluded that there is insufficient evidence to show a beneficial effect of stretching on injury risk and movement performance. [8-10] It is well established that chronic stretching can effectively increase joint range of motion (ROM). [11-13] The increased joint motion after stretch training has been attributed to mechanical and neural factors as well as tolerance to stretch. [13,14]

Stretching is commonly utilized to stretch the muscle and increase the ROM around the joint and theorized to improve balance performance. [7, 8, 10, 11, 14] Normal functioning of the musculoskeletal system is imperative for balance maintenance. The decreased flexibility in the elderly also decreases their ability to recover quickly from a perturbation. Lack of necessary range of motion (ROM) would decrease the effectiveness of hip and ankle strategies. If a person is unable to counteract a perturbation due to lack of flexibility and lack of appropriate ROM, the perturbation may result in fall. Prior research has shown that there is a correlation between short hip and ankle muscles and increased falls in the elderly. [15,16]

As age increases, the stiffness around the joints increases resulting in decreased flexibility. Flexibility is dependent on the viscoelasticity of muscle, ligaments, and other connective tissue. [17, 18] The maintenance of good balance requires adequate muscle flexibility. In elderly people, there is increased stiffness in the joints which might have a detrimental effect on balance. The objective of this research study is to find the effectiveness of stretching of all major muscle groups of the legs that might have an effect on balance in the elderly population.

Methods

Subjects:

Advertisement in the form of posters and verbal announcement was made for voluntary participation of the subjects in the geriatric homes and outpatient department of the university. The study design was a pretest and posttest single group experimental study design. All the subjects were recruited through convenience sampling. A total of 68 asymptomatic subjects were recruited (30 male and 30 female) with mean age group of 61 years in male and 58 years in female. As the study included human subjects, ethical clearance was obtained from university ethics committee and all the subjects read the subject information letter and signed the informed consent prior to the commencement of the study. Asymptomatic subjects with either gender were included in the study. Subjects were excluded if they had any history of acute medical illness; symptoms of unstable angina or congestive heart failure; pulmonary diagnosis or symptoms of emphysema, chronic obstructive pulmonary disease, or asthma; neurologic diagnosis, including Parkinson's disease, stroke, brain injury, cerebellar disease, myelopathy; myopathy, peripheral neuropathy, or active radiculopathy; Major orthopedic diagnosis in the lower back, pelvis,

or lower extremities, including hip or other fracture since the age of 50, fused joint, joint replacement, or amputation; Active joint or musculoskeletal pain; Gait or balance disorder, history of falls and Regular use of an assistive device for walking.

Method of data collection:

Single limb stance test

Eligible subjects were asked to stand barefoot on the limb of their choice, with the other limb raised so that the raised foot was near but not touching the ankle of their stance limb.[19] Each subject was asked to focus on a spot on the wall at eye level in front of him, for the duration of the eyes open test. Prior to raising the limb, the subject was instructed to cross his arms over the chest. The investigator used a stopwatch to measure the amount of time the subject was able to stand on one limb. Time was commenced when the subject rose to the foot off the floor. Time was ended when the subject either: (1) use his arms (i.e. uncrossed arms), (2) uses the raised foot (moves it towards or away from the standing limb or touches the floor), (3) moves the weight-bearing foot to maintain his balance (i.e. rotates foot on the ground), (4) a maximum of 45 seconds would be elapsed, or (5) opens eyes on eyes closed trials. The procedure was repeated 3 times and each time was recorded on the data collection sheet. The best and the average of the 3 trials were also being recorded. [19] Subjects performed 3 trials with the eyes open, and 3 trials with the eyes closed, alternating between the conditions.

Berg functional balance test

The subject was asked to maintain a given position for a specific time. Progressively more points are deducted if the time or distance requirements are not met, if the subject's performance warrants supervision, or if the subject touches an external support or receives assistance from the examiner. The Subjects understood that they must maintain their balance while attempting the tasks. [20] The choices of which leg to stand on or how far to reach was left to the subject. Poor judgment will adversely influence the performance and the scoring. Equipment required for testing are a stopwatch or watch with a second hand, and a ruler or other indicator of 2, 5 and 10 inches (5, 12.5 and 25 cm). [20]

Stretching Procedure:

All the subjects who meet the inclusion criteria were included in the study and informed consent was obtained from the subjects. Demographic variables like Age, sex, height, weight, BMI etc. were documented from all the subjects. General instructions on how to perform a stretching session was explained. One researcher trained all the participants in the program. Pre balance evaluation, i.e. single limb stance time in seconds and Berg balance score was recorded before the commencement of the stretching program.

The treatment included performing hip flexor, hamstring and gastronomies stretching exercises. [10] The subjects used their own body weight rather than the force of an external weight or an assisting person. Subjects were instructed to perform 4 sets of stretches, holding each stretch for 30 seconds and alternating the right and left limb (8 stretches in total). [10] The stretching exercises proceeded and were followed by a warm-up and cool-down period. The warm-up period consisted of (1) sidestepping to the right and then to the left 4 times in each direction, (2) 3 sets of walking forward 3 steps, clapping, and walking backward 3 steps and clapping, and (3) holding on to a chair for balance, 4 sets of lifting the right knee up and then the left knee. The cool-down period was consisted of (1) taking a deep breath in while bringing both arms over the head and letting the breath out while bringing the arms back down, (2) shaking out the arms and legs, and (3) using a chair if needed for balance, rotating the wrists and ankles alternatively, clock wise and then counterclockwise.

The warm-up and cool-down periods were identical between all subjects. Participants were asked to perform 5-minute session twice daily for 10 weeks in their own homes. [21] They each received a copy of their respective exercise program. Participants were also being asked to keep a logbook, to check off each day, whether they performed the exercise, and to submit a weekly log sheet at the end of each week of the 10-week program. Participants were evaluated for single limb stance time (sec) and berg balance score following the 10 weeks stretching program.

Data analysis and Results:

Statistical analysis was performed by using SPSS software for windows (version 16) and p value was set as 0.005. Descriptive statistics were used to analyze baseline data for demographic data. Paired t test was used to find the significance of the parameters between pre and posttest differences.

60 subjects who met inclusion criteria were included. During 10 weeks of stretching program10 subjects (four males, six females) discontinued the trial. Reasons for discontinuing were: admitted to hospital or nursing home (n=4), private reasons (n=5) and moved to other town (n=1). Pre post analysis was done for 50 subjects. The descriptive statics of the study population are summarized in table 1. Single limb stance time with eyes open (table 2), eyes closed (table 3), and berg balance score (table 4) improved after 10 weeks of lower limb stretching exercises.

Table: 1: Descriptive characteristics of subjects in the study

Single limb stance time with eyes open	**n**	**Mean±SD**	**SEM**	**95% Confidence Interval of the Difference**		**P value**
				Lower	Upper	
Pre-treatment (seconds)	50	32.1±4.2	0.45	-6.3	-4.5	<0.001
Post-treatment (seconds)	50	37.6±3.9				

Table 2: Pre-post single limb stance time with eyes open changes analyses using paired t-test

Single limb stance time with eyes closed	**n**	**Mean±SD**	**SEM**	**95% Confidence Interval of the Difference**		**P value**
				Lower	Upper	
Pre-treatment (seconds)	50	4.6±0.9	0.11	-1.1	-0.6	<0.001
Post-treatment (seconds)	50	5.6±1.1				

Table 3: Pre-post single limb stance time with eyes closed changes analyses using paired t-test

	n	**Age (years)** **Mean±SD**	**Height (Cm)** **Mean±SD**	**Weight (Kg)** **Mean±SD**
Male	26	61±5.5	165.6±4.3	71.5±6.9
Female	24	58±4.1	156.6±3.7	63±8.2

Table 4: pre post Berg balance score changes analysis using Paired t-test

Berg Balance score	n	Mean±SD	SEM	95% Confidence Interval of the Difference		P value
				Lower	Upper	
Pre-treatment	50	41.5±3.1	0.66	-8.9	-6.2	<0.001
Post-treatment	50	49.1±4.0				

Discussion

This study demonstrated that the effects of lower limb muscle stretching significantly improved single limb stance time and balance which was evaluated using berg balance score. Importantly, our combination of total volume and level of intensity of the present static- stretching protocol of the lower limb muscles was effective at increasing the lower limb ROM by 20 to 30% in all the joints, thereby changing the balance measures and single limb stance time both in eyes open and eyes closed.

Single limb stance time is a one-leg standing balance which is a promising predictive marker for injurious falls in elderly. Single limb stance time, which is the most commonly utilized measures of balance, is correlated with other measures of physical performances. [22 23] The subjects improved significantly in both eyes open and eyes closed situations reflecting the positive effect of lower extremity stretching. The improvement seen in this study is more significant than those in other studies winter et al, [16] Jonsson, et al, [24] and Campbell et al. [6]

Berg balance scale is one of the best functional balance tests to test balances in geriatrics. The BBS has been shown to have excellent inter-rater (ICC = 0.98) and intra-rater reliability (ICC = 0.98), and is internally consistent (0.96). All subjects participated in this study were ambulating independent and the reason for using berg balance scale in this study is justified.

The mean difference in improvement after 10 weeks of the intervention period on berg balance scale was 7 points. This improvement was considered clinically relevant at the outset of the study. Almost 70 percent of male and female showed improvement of more than 5 points on the berg balance scale. It was encouraging to notice in this study that balance function can be improved in people over 60 years of age by an intense 10 weeks lower extremity muscle stretching program.

The mean improvement on the berg balance scale as a result of the intervention correspond with the results reported by Wolf et al, [25] Harada et al. [26] and Shumway-Cook et al. [27] All these studies used an individualized exercise programme in order to improve functional balance performance. All the results of the aforementioned and this study show that the deterioration of balance function can be reversed with training.

The reasons for improvement in balance can be attributed to the below theory. Stretching might have induced changes in both peripheral neural (proprioception) and mechanical output (musculo-tendinous unit or stiffness) affecting the ability to adapt adequately to the stability challenges. [28] The prolonged static- stretching protocol may have reduced the stiffness of the joint, fascia, and musculo-tendinous unit, thus hindering balance during the single leg balance task. These changes might affect the muscle afferent input to the central nervous system and the muscle output during balance. [28] However, the absolute mean change in the single limb stance time both in eyes open and closed and balance from pre- to post-stretching values increased in both the stretched lower limbs.

The proper duration and frequency are very important when applying stretching techniques. Bandy and Irion stated that applying a stretching technique one time for 30 seconds was the most effective duration, because the extensibility was not increased further in applications lasting more than 30 seconds. [21, 29, 30] In this study, we examined the effects on the muscle extensibility of applying the static stretching technique four times for 30 seconds.

The physical therapeutic intervention presented in this study appeared to be

successful and can be applied to people at high age with poor balance. Yet, it should be noticed that participating subjects had a reasonable good cognition. Therefore, results might have been different if subjects with poor cognitive function were included. Another limitation of this study is that it is a single group pre-test post-test study design. There is a further scope to conduct randomized controlled trial having a control group to see if lower extremities stretching significantly improve balance.

Conclusion

10 weeks of lower extremity stretching exercises are effective in improving Single limb stance time and berg balance score so lower extremity stretching exercises are effective in improving balance and thereby decreasing falls in elderly.

References:

1. Das CP, Joseph S. Falls in elderly. *Journal of the Indian Medical Association.* 2005;103(3):136, 138, 140 passim-136, 138, 140 passim.
2. Tinetti ME, Speechley M, Ginter SF. Risk factors for falls among elderly persons living in the community. *New England journal of medicine.* 1988;319(26):1701-1707.
3. Province MA, Hadley EC, Hornbrook MC, et al. The effects of exercise on falls in elderly patients: a preplanned meta-analysis of the FICSIT trials. *Jama.* 1995;273(17):1341-1347.
4. Blake A, Morgan K, Bendall M, et al. Falls by elderly people at home: prevalence and associated factors. *Age and ageing.* 1988;17(6):365-372.
5. Lundin-Olsson L, Nyberg L, Gustafson Y. "Stops walking when talking" as a predictor of falls in elderly people. *The Lancet.* 1997;349(9052):617.
6. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *Bmj.* 1997;315(7115):1065-1069.
7. Gillespie LD, Gillespie WJ, Robertson MC, Lamb SE, Cumming RG, Rowe BH. Interventions for preventing falls in elderly people. *Cochrane Database Syst Rev.* 2003;4.
8. Carmeli E, Kessel S, Coleman R, Ayalon M. Effects of a treadmill walking program on muscle strength and balance in elderly people with Down syndrome. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.* 2002;57(2):M106-M110.
9. Tsang WW, Hui-Chan CW. Effects of exercise on joint sense and balance in elderly men: Tai Chi versus golf. *Medicine and science in sports and exercise.* 2004;36(4):658-667.
10. Behm DG, Bambury A, Cahill F, Power K. Effect of acute static stretching on force, balance, reaction time, and movement time. *Medicine and Science in Sports and Exercise.* 2004;36:1397-1402.
11. Godges JJ, MacRae H, Longdon C, Tinberg C, MacRae P. The effects of two stretching procedures on hip range of motion and gait economy. *Journal of Orthopaedic & Sports Physical Therapy.* 1989;10(9):350-357.
12. Murphy JR, Di Santo MC, Alkanani T, Behm DG. Aerobic activity before and following short-duration static stretching improves range of motion and performance vs. a traditional warm-up. *Applied Physiology, Nutrition, and Metabolism.* 2010;35(5):679-690.
13. Shellock FG, Prentice WE. Warming-up and stretching for improved physical performance and prevention of sports-related injuries. *Sports Medicine.* 1985;2(4):267-278.
14. Decoster LC, Cleland J, Altieri C, Russell P. The effects of hamstring stretching on range of motion: a systematic literature review. *Journal of Orthopaedic & Sports Physical Therapy.* 2005;35(6):377-387.
15. Rubenstein LZ, Josephson KR, Trueblood PR, et al. Effects of a group exercise program on strength, mobility, and falls among fall-prone elderly men. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences.* 2000;55(6):M317-M321.
16. Winter DA, Patla AE, Frank JS, Walt SE. Biomechanical walking pattern changes in the fit and healthy elderly. *Physical therapy.* 1990;70(6):340-347.

17. Nordin M, Lorenz T, Campello M. Biomechanics of tendons and ligaments. *Basic biomechanics of the musculoskeletal system. 3rd ed. Philadelphia: Lippincott Williams & Wilkins.* 2001:102-125.
18. Kannus P. Etiology and pathophysiology of chronic tendon disorders in sports. *Scandinavian journal of medicine & science in sports.* 1997;7(2):78-85.
19. Bohannon RW. Single Limb Stance Times: A Descriptive Meta-Analysis of Data From Individuals at Least 60 Years of Age. *Topics in Geriatric Rehabilitation.* 2006;22(1):70-77.
20. Thorbahn LDB, Newton RA. Use of the Berg Balance Test to predict falls in elderly persons. *Physical therapy.* 1996;76(6):576-583.
21. Feland JB, Myrer JW, Schulthies SS, Fellingham GW, Measom GW. The effect of duration of stretching of the hamstring muscle group for increasing range of motion in people aged 65 years or older. *Physical Therapy.* 2001;81(5):1110-1117.
22. Hasan SS, Lichtenstein MJ, Shiavi RG. Effect of loss of balance on biomechanics platform measures of sway: influence of stance and a method for adjustment. *Journal of biomechanics.* 1990;23(8):783-789.
23. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. *Journal of gerontology.* 1990;45(6):M192-M197.
24. Jonsson E, Seiger Å, Hirschfeld H. One-leg stance in healthy young and elderly adults: a measure of postural steadiness? *Clinical biomechanics.* 2004;19(7):688-694.
25. Wolf B, Feys H, De Weerdt W, van der Meer J, Noom M, Aufdemkampe G. Effect of a physical therapeutic intervention for balance problems in the elderly: a single-blind, randomized, controlled multicentre trial. *Clinical rehabilitation.* 2001;15(6):624-636.
26. Stevenson TJ. Detecting change in patients with stroke using the Berg Balance Scale. *Australian Journal of Physiotherapy.* 2001;47(1):29-38.
27. Shumway-Cook A, Gruber W, Baldwin M, Liao S. The effect of multidimensional exercises on balance, mobility, and fall risk in community-dwelling older adults. *Physical therapy.* 1997;77(1):46-57.
28. Lima BN, Lucareli PR, Gomes WA, et al. The acute effects of unilateral ankle plantar flexors static-stretching on postural sway and gastrocnemius muscle activity during single-leg balance tasks. *Journal of sports science & medicine.* 2014;13(3):564.
29. Kerrigan DC, Xenopoulos-Oddsson A, Sullivan MJ, Lelas JJ, Riley PO. Effect of a hip flexor [ndash] stretching program on gait in the elderly. *Archives of physical medicine and rehabilitation.* 2003;84(1):1-6.
30. Lord SR, Ward JA, Williams P, Strudwick M. The effect of a 12-month exercise trial on balance, strength, and falls in older women: a randomized controlled trial. *Journal of the American Geriatrics Society.* 1995;43(11):1198-1206.