Effect of a Static Calf Muscle-Tendon Unit Stretching Program on Ankle Dorsiflexion Range of Motion of Older Women

Eric G. Johnson, PT, DPTSc;[1] Bruce D. Bradley, PT, DPTSc;[1] Kimberly R. Witkowski, DPT;[1] Rose Y. McKee, DPT;[1] Christopher L. Telesmanic, DPT;[1] Andre S. Chavez, DPT;[1] Karen L. Kennedy, MPT;[1] Grenith J. Zimmerman, PhD[2]

[1] Loma Linda University, Department of Physical Therapy, Loma Linda, CA

[2] Loma Linda University, Department of Allied Health Studies, Loma Linda, CA

ABSTRACT

Background and Purpose: While there has been considerable research on stretching, a paucity of research has focused on stretching of the calf muscle-tendon unit (MTU) in older women. Because limited ankle dorsiflexion range of motion (ROM) is associated with gait abnormalities and increases the risk of falls in the elderly, we investigated the effect of static stretching on flexibility of the calf MTU of healthy elderly adults. **Methods:** Twenty healthy female volunteers, 76 to 91 years of age, were recruited from Linda Valley Villa, an independent living center. Subjects performed a static stretching program 5 days a week for 6 weeks. Passive ankle dorsiflexion ROM was taken prior to beginning the stretching program and 3 days after the last stretching day. **Results:** Mean increase in passive ankle dorsiflexion ROM was 12.3° (SD= 4.4°) ($p < .001$). **Conclusion:** A 6-week stretching program is capable of provoking a significant increase in ankle dorsiflexion ROM for elderly women.

Key Words: stretching, exercise, elderly, women

INTRODUCTION

According to the *Guide to Physical Therapist Practice,* stretching is an important component of the preferred practice patterns in the treatment of musculoskeletal, neuromuscular, cardiovascular, pulmonary, and integumentary diagnoses.[1] While there has been considerable research on stretching, a paucity of research has focused on stretching of the calf muscle-tendon unit (MTU) in older women.[2-4] Because reduced ankle dorsiflexion range of motion (ROM) can impact gait and is associated with falls in the elderly population, identifying successful physical therapy interventions to improve ankle ROM is warranted. The purpose of this study was to investigate the effects of a static calf MTU stretching program on ankle dorsiflexion ROM in healthy adult women 65 years of age and older.

Address all correspondence to: Eric Glenn Johnson, Loma Linda University, Department of Physical Therapy, School of Allied Health Professions, Nichol Hall Office #1900, Loma Linda, CA 92350, Ph: 909-558-4632 ext 47471, Fax: 909-558-4291 (ejohnson@llu.edu).

METHODS

Subjects

Twenty healthy female volunteers, 76 to 91 years of age, were recruited for the study. Subjects were included if they had no evidence of lower extremity dysfunction as assessed by a visual observation of gait, had less than 10° of passive ankle dorsiflexion ROM, and were functionally independent. All subjects voluntarily signed an informed consent document approved by the Loma Linda University Institutional Review Board prior to participation in the study. Subjects were dismissed from the study if they missed 2 or more stretching sessions in a single week, or missed a total of 6 or more sessions during the course of the study.

Procedures and Measurements

All pre- and postintervention goniometric measurements were taken from the right lower extremity by the same researcher. Prior to data collection, goniometric intra-tester reliability for passive ankle dorsiflexion ROM was established (intraclass correlation coefficient = 0.95). Measurement of passive ankle dorsiflexion ROM has been described by Norkin and White.[5] We modified the procedure by having subjects sit in a long sit position on a treatment table with knees fully extended. The researcher stabilized the tibia and fibula of the right lower extremity to prevent knee motion. The researcher then passively dorsiflexed the subject's ankle with enough force to encounter notable tension in the calf MTU, as described by Bohannon et al.[6] The ankle was maintained in subtalar joint neutral during the measurements and subjects were instructed to not provide any active assistance. The goniometer was placed with the center of the fulcrum over the lateral aspect of the lateral malleolus, the proximal arm with the lateral midline of the fibula using the head of the fibula for reference, and the distal arm parallel to the lateral aspect of the fifth metatarsal. Measurements of all subjects were taken prior to beginning the stretching protocol and 3 days after the last stretching day by the same researcher. All postintervention measurements were taken with the researcher blind to the preintervention measurements.

Subjects were instructed how to perform the stretching program on the first day of the study and researchers were present on all subsequent stretching days to ensure proper implementation of the stretching protocol. Subjects performed a static stretch to both left and right calf MTUs while standing and wearing shoes. Subjects placed 1 foot in front of the other, at a comfortable and stable stepping stance, with hands resting on the back of a chair for stability. Subjects then leaned forward toward the chair until a stretch was felt, keeping their back lower limb straight, and bending their front lower limb. The stretch was held for 60 seconds and repeated 4 times on each lower limb. Subjects performed the stretching protocol with supervision once per day, 5 days per week for 6 weeks (Figure 1).

The SPSS (Version 12.0) statistical package was used for data analysis. Descriptive statistics included means and standard deviations of pre- and postintervention ROM measurements. A paired t-test was used to compare the means.

RESULTS

Data were analyzed from 13 subjects, ages of 76 to 91 years (mean=83.8, SD=4.7). One subject was excluded from the study secondary to an acute medical problem, 3 subjects missed 2 or more stretching sessions in a single week, and 3 subjects did not return after the first week. Mean preintervention dorsiflexion ROM was -11.1° (SD=4.6°). Mean postintervention dorsiflexion ROM was 1.2° (SD=3.0°). A statistically significant increase of 12.3° ankle dorsiflexion ROM (SD=4.4°) was demonstrated postintervention ($p < 0.001$).

Figure 1. Stretching position for calf MTU.

DISCUSSION

As a person advances through life, the structure and composition of skeletal muscle changes and the cross sectional area of a muscle belly decreases, mainly because it is infiltrated with fat and other connective tissue.[7-9] Gajdosik et al[10] investigated the influence of age on length and passive elastic stiffness characteristics of the calf MTU of women grouped by age (young, middle-aged, and elderly). They used an isokinetic dynamometer to passively stretch the right calf MTU to measure the maximal angle of available dorsiflexion and found that ROM was significantly decreased in older women.

Improving connective tissue compliancy and increasing the number of serial sarcomeres are both major contributing factors in musculoskeletal flexibility and are influenced by slow, low-intensity, and long-duration stretches.[11,12] Taylor et al[13] studied the viscoelastic behavior of the MTUs in an animal model and found that "after 4 stretches there was little alteration of the MTU, implying that a minimum number of stretches will lead to most of the elongation in repetitive stretching." The stretching protocol used in the current study was based on the work of Feland et al[12] who investigated the effect of duration of stretching of the hamstring muscle group for increasing ROM in people aged 65 years or older. They determined that 4 repetitions with a 60 second hold at the terminal position once per day, 5 times per week, for 6 weeks produced the greatest increases in hamstring flexibility and knee extension ROM. The results of the current study suggest that the stretching protocol described by Feland et al[12] for the hamstring muscles can be effectively applied to the calf MTU in elderly females.

Gajdosik et al[14] reported a mean increase of 5.1° of ankle dorsiflexion ROM after an 8-week home stretching program. In their study, 10 subjects with a mean age of 73.1 years performed 10 repetitions with a 15-second hold at the terminal position one time per day, 3 times per week, for 8 weeks. Subjects in the current study made considerably more ankle dorsiflexion ROM gains, 12.3° versus 5.1°, respectively. This is likely because the mean preintervention ankle dorsiflexion ROM was markedly less (-11.1° versus 0.2°, respectively). Also, the stretching protocol between the 2 studies was quite different. Subjects in the current study performed a 6-week supervised stretching program consisting of 4 repetitions with a 60 second hold at the terminal position once per day, 5 times per week, for 6 weeks. Additionally, the total number of stretching seconds per subjects was approximately 50% greater in the current study. Despite the differences in protocols, results from both studies strongly suggest that static stretching of the calf MTU increases ankle dorsiflexion ROM in the elderly.

Pratt and Bohannon[15] examined the effect of a 3-minute passive stretch on ankle dorsiflexion in 24 healthy adults with a mean age of 24.7 years. Subjects stood on a platform and stretched their calf MTUs by lowering their heels for 3 minutes

on 3 consecutive days. The results of their study revealed that significant improvements in passive ROM were made each day ($p < .0005$), however, no lasting changes in passive ROM were sustained over the 3 days. In the current study, all postintervention measurements were taken 3 days after the last stretching day and we were able to demonstrate a lasting, or plastic change in calf MTU passive ROM.

Bandy et al[16] found that 1 repetition of static stretching sustained for 30 seconds at the terminal position once per day, 5 times per week, for 6 weeks was optimal in making plastic changes in hamstring flexibility in young adults. As discussed previously, Feland et al[12] found that 4 repetitions with a 60 second hold at the terminal position once per day, 5 times per week, for 6 weeks produced the greatest increases in hamstring flexibility and knee extension ROM in adults 65 years of age and older. Rehabilitation specialists should consider the results of these studies as well as the results of the current study when prescribing home stretching programs to their patients.

Research has shown that a reduction in muscle flexibility, reduced gait speed, and unsteady gait contribute to increased risk of falling in the elderly.[17-21] Mecagni et al[22] determined that correlations exist between ankle ROM and balance in 34 community dwelling elderly women with a mean age of 74.7 years. They concluded that improving ankle ROM "may increase the effectiveness of clinical and community interventions designed for improving balance and reducing falls in elderly women."

Since ankle dorsiflexion ROM is an important component for normal gait, an argument can be made that reducing ankle dorsiflexion ROM impairments in elderly people will decrease their risk for falling. Because the foot clears the ground by just 1 centimeter during the mid-swing phase of swing limb advancement, dorsiflexion of at least neutral is desireable.[23] Another important consideration in gait is that 5° to 10° of ankle dorsiflexion are required in order to progress from midstance to terminal stance.[23] It stands to reason that inability to progress from midstance to terminal stance shortens the stride length and contributes to reduced gait speed and unsteadiness.

There were several limitations of this study including the fact that we did not include a control group. Nevertheless, the marked improvement in postintervention ankle dorsiflexion ROM strongly suggests that the ankle dorsiflexion ROM improvements were the result of the calf MTU stretching protocol. There was also potential for examiner bias because of the lack of examiner blinding. Additionally, the small sample size does not allow us to generalize the results of this study to the population at large. A single blind randomized study with a larger sample size is necessary at this point in order to confirm the results of this pilot study. Also, the effect of improved ankle dorsiflexion ROM postintervention on gait and balance in the elderly is recommended for further research.

CONCLUSION

The results of this pilot study demonstrated that a stretching protocol consisting of 4 static stretches with a 60-second hold, once per day, 5 times per week for 6 weeks significantly improved ankle dorsiflexion ROM in elderly females. The ROM improvements were maintained 3 days after the last stretching day.

ACKNOWLEDGEMENT

The authors thank Kathleen Gerarty, Linda Valley Villa Activities Director, for her assistance and support.

REFERENCES

1. American Physical Therapy Association: Guide to Physical Therapist Practice. 2nd ed. *Phys Ther*. 2001;81:1.
2. Harvey L, Herbert R, Crosbie J. Does stretching induce lasting increases in joint ROM? A systematic review. *Physiother Res Int*. 2002;7:1-13.
3. Decoster LC, Cleland J, Altieri C, Russell P. The effects of hamstring stretching on range of motion: a systematic literature review. *J Orthop Sports Phys Ther*. 2005;35:377-387.
4. Radford JA, Burns J, Buchbinder R, Landorf KB, Cook C. Does stretching increase ankle dorsiflexion range of motion? A systematic review. *Br J Sports Med*. 2006;40:870-875.
5. Norkin C, White D. *Measurement of Joint Motion: A Guide to Goniometry.* 3rd ed. Philadelphia, Pa: F.A. Davis Company; 2003:256-257.
6. Bohannon RW, Tiberio D, Zito M. Selected measures of ankle dorsiflexion range of motion: differences and intercorrelations. *Foot Ankle*. 1989;10:99-103.
7. Rogers MA, Evans WJ. Changes in skeletal muscle with aging: effects of exercise training. *Exerc Sport Sci Rev.*1993;21:65-102.
8. Nurmi L, Luthje P. Incidence and costs of falls and fall injuries among elderly in institutional care. *Scand J Prim Health Care.* 2002;20:118-122.
9. Fuller F. Falls in the elderly. *Am Fam Physician*. 2000;61:2159-2168, 2173-2174.
10. Gajdosik RL, Vander Linden DW, Williams AK. Influence of age on length and passive elastic stiffness characteristics of the calf muscle-tendon unit of women. *Phys Ther.* 1999;79:827-838.
11. Williams PE. Use of intermittent stretch in the prevention of serial sarcomere loss in immobilised muscle. *Ann Rheum Dis*. 1990;49:316-317.
12. 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. *Phys Ther*. 2001;81:1110-1117.
13. Taylor DC, Dalton JD, Seaber AV, Garrett WE. Viscoelastic properties of muscle-tendon units; the biomechanical effects of stretching. *Am J Sports Med.* 1990;18:300-309.
14. Gajdosik RL, Vander Linden DW, McNair PJ, Williams AK, Riggin TJ. Effects of an eight-week stretching program on the passive-elastic properties and function of the calf muscles of older women. *Clin Biomech*. 2005;20:973-983.
15. Pratt K, Bohannon R. Effects of a 3-minute standing stretch on ankle dorsiflexion range of motion. *J Sport Rehab*. 2003;12:162-173.

16. Bandy WD, Irion JM, Briggler M. The effect of time and frequency of static stretching on flexibility of the hamstring muscles. *Phys Ther.* 1997; 77:1090-1096.
17. Carter ND, Kannus P, Khan KM. Exercise in the prevention of falls in older people. *Sports Med.* 2001;31:427-438.
18. Snow CM. Exercise effects on falls in frail elderly: Focus on strength**.** *J Appl Biomech*. 1999;14:4-91.
19. Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. *Sports Med.* 2004;34:329-348.
20. Fried LP, Guralnik JM. Disability in older adults: evidence regarding significance, etiology, and risk. *Am Geriatr Soc.* 1997; 45:92-100.
21. Vanitallie TB. Frailty in the elderly: contributions of sarcopenia and visceral protein depletion. *Metabolism*. 2003;52:22-26.
22. Mecagni C, Smith JP, Roberts KE, O'Sullivan SB. Balance and ankle range of motion in community-dwelling women aged 64 to 87 years: a correlational study. *Phys Ther.* 2000;80:1004-1011.
23. Pathokinesiology Service and Physical Therapy Department: *Observational Gait Analysis Handbook*. Downey, Calif: Los Amigos Research and Education Institute, Inc; 2001:10-12.