J Int Acad Phys Ther Res 2016; 7(1): 919-924
ISSN 2092-8475

www.iaptr.org
http://dx.doi.org/10.20540/JIAPTR.2016.7.1.919

The Effect of Soleus Passive Stretching on the Range of Motion of the Ankle Joint

In this study, 20 men and women in their 20s were divided into a footboard passive stretching group and a manual passive stretching group. After stretching was applied to the soleus for 5 weeks, a comparative analysis was performed on the range of motion(ROM) of the ankle joint to determine changes in the flexibility of the soleus. Both the footboard stretching group and manual stretching group first performed stretching for 15 sec, followed by a 10-sec break. One set consisted of performing the above process twice consecutively, and each group had to perform five sets in total. A goniometer was used as a measuring instrument. The results of the experiment were analyzed using a nonparametric analysis, Wilcoxon signed rank test, and Mann-Whitney test. SPSS WIN 18.0 was employed for the statistical analysis. In terms of the comparison of the flexibility before and after the experiment according to the different interventions, the application of footboard stretching to the soleus for 5 weeks resulted in 3.2° right dorsiflexion (p=.009), 6.98° right plantar flexion(p=.008), 4.14° left dorsiflexion(p=.005), and 10.97° left plantar flexion(p=.007), which were all statistically significant increases. The application of manual stretching led to 6.04° right dorsiflexion(p=.005), 12.14° right plantar flexion(p=.005), 7.00° left dorsiflexion (p=.008), and 16.38° left plantar flexion(p=.005). Therefore, both footboard stretching and manual stretching were effective in enhancing the flexibility of the soleus. However, statistically significant larger increases in the ROM of the ankle joint were observed in the manual stretching group.

Key words: *Foot Board Stretching; Manual Stretching; Soleus; Ankle Joint ROM*

Hyun Sook Hwang[a], Jung Hyun Choi[b]

[a]Department of Physical Therapy, Cheju Halla University, [b]Namseoul University, Cheonan, Korea

Received : 10 November 2015
Revised : 12 December 2015
Accepted : 21 December 2015

Address for correspondence
Jung Hyun Choi, PT. Ph.D
Department of Physical Therapy, Namseoul University, 21 Maeju-ri, Sunghwan-eup, Cheonan, Korea
Tel: 82-41-580-2534
E-mail: rightmind@nsu.ac.kr

INTRODUCTION

Many people today do not take part in regular physical activities and mostly work or study in a sitting posture for long hours, resulting in reduced flexibility(1). The latter is emerging as a, which cause musculoskeletal disorders(2). With regard to the ability to perform musculoskeletal exercises, not only the contractile force of muscles but also the range of motion(ROM) and the flexibility of muscles and tendons play important roles(3). Flexibility refers to the attainable ROM in a joint or series of joints, which is affected by muscles, tendons, ligaments, and skeletons(4). The functioning of the ligaments or muscles that surround a joint region determines the level of flexibility (defined as the ROM). Flexibility is also a basic element underlying the efficiency of activities and exercise performance in daily life(5).

Stretching exercises can extend connective tissues, such as muscles, tendons, and ligaments, through the relaxation of actin and myosin(6), minimize the possibility muscle or tendon injuries, relieve muscle pain, and improve the ability to perform exercises(4)(7-9). Stretching is a warm up exercise that prevents injuries by relaxing muscles, thereby increasing their lengths(10). It is performed to reduce muscle tension or soreness after physical activities and to increase the ROM(11). Stretching not only improves flexibility but also prevents various muscle and joint disorders and increases muscle strength by helping balance and coordination, thus allowing optimum movements(12).

If one's flexibility increases through stretching exercises, he/she can more naturally move the muscles and joints within the full ROM and prevent energy consumption caused by unnecessary movements because of improvements in the ability of the coordination necessary for accurate motor manifestations. In addition, stretching generates increases in the ROM via muscle extension(10)(13, 14) and increases the temperature of muscles by facilitating smooth blood circulation. Therefore, stretching is one of the most effective exercise methods for improving flexibility(4)(7–9).

In society today, the labor environment is gradually shifting toward office work and automation. With this trend, a lack of physical activities and exercises is becoming evident among workers(15). In particular, a lack of flexibility in the ankle region results in frequent exercise-related injuries, not only in adults but also in teenagers. In terms of physical therapy-based approaches, footboard stretching and manual stretching are mainly used as stretching methods for improving ankle flexibility.

A stretching is performed to prevent injuries and increase flexibility, and undoubtedly, every type of stretching increases the ROM and flexibility of muscles and tendons(16), but the effects depend on the type of stretching and mechanism(17–20).

The purpose of this study was to examine the effects of different types of stretching on changes in the flexibility of the soleus. To this end, the study measured the ROM of the ankle joint, following different types of stretching. Few previous studies have reported the results of comparing footboard stretching and manual stretching. In the present study, the subjects were divided into a footboard stretching group and a manual stretching group to obtain basic data on the effects of these stretching exercises on changes in the flexibility of the two groups and identify the effects of the different types of stretching on the flexibility of the soleus.

METHODS

Subjects

The subjects of this study were 20 individuals in their 20s(10 men and 10 women). A full explanation of this study was given to the subjects, and consent to participate in the study was obtained. The general characteristics of the subjects are shown in Table 1.

The experiment was conducted over a 5 week period between 7 September and 7 October 2015, and the subjects were instructed not to participate in any physical activity from 4 September 2015 when preliminary measurements were taken.

Experimental method

For the application of passive stretching, the subjects were divided into a footboard stretching group and a manual stretching group. This experimental setting was designed to examine changes in the flexibility of the soleus according to the different groups. The participants took part in the passive stretching program twice a week over a 5 week period.

Both the footboard stretching group and manual stretching group performed stretching for 15 sec, followed by a 10 sec break. One set consisted of performing this process twice consecutively, and each group performed five sets in total. In the footboard stretching group, the subjects set the angle of the footboard at 30°, stood on the footboard with their backs against the wall and ankles dorsiflexed, and maintained this position for 15 secs. They then returned to their original location and took a break for 10 sec.

In the manual stretching group, the subjects performed a long sitting position in which they sat on a mat with their legs stretched out. Under the direction of the teacher, each subject then maintained the dorsiflexion of one leg for 15 sec, while

Table 1. General characteristics of the subjects

Gender	Age(yr)	Height(cm)	Weight(kg)	BMI
Male (n=10)	20	174.10±3.63	71.00±9.27	23.39±2.92
Female (n=10)	20	161.50±3.62	57.80±8.66	21.61±2.46

maintaining the direction, speed, and intensity of extension at consistent levels. Upon completion, the subjects returned to their original location and took a break for 10 sec. After they had performed five sets of stretching on one ankle, five sets of stretching were likewise performed on the opposite ankle.

Before the start of the experiment, each subject's height, weight, and body mass index(BMI) were measured. In addition, the ROM (dorsiflexion and plantar flexion) of the ankle joint was measured before the start of the experiment and 5 weeks after the application of the stretching exercise.

A goniometer was used as a measuring instrument, and the average of three consecutive measurements was taken to reduce the error of the measured values.

Data analysis

The statistical analyses were performed using SPSS WIN 18.0. When the Kolmogorov-Smirnov test was performed, some of the measured values did not show a normal distribution. Therefore, they were analyzed using a nonparametric analysis($p>.05$). The Wilcoxon signed-rank test was performed to compare differences before and after the experiment according to the interventions. The Mann-Whitney test was performed to compare homogeneity between the two groups and analyze the changes in flexibility according to the interventions.

RESULTS

According to the results of the Mann-Whitney test performed before the experiment to confirm the homogeneity between the footboard stretching group and manual stretching group, the two groups did not show statistically significant differences($p>.05$)(Table 2).

In the comparisonpre and post intervention comparison, the application of the footboard stretching to the soleus resulted in a statistically significant increase in right dorsiflexion 5 weeks after the intervention(M=14.50) compared to before the intervention(M=11.30)(Z=-2.618, p=.009). The right plantar flexion also showed a statistically significant increase 5 weeks after the intervention(M=50.00) compared to before the intervention(M=43.02)(Z=-2.666, p=.008). The left dorsiflexion showed a statistically significant increase 5 weeks after the intervention(M=14.20) compared to before the intervention(M=10.06)(Z=-2.805, p=.005). The left plantar flexion exhibited a statistically significant increase 5 weeks after the intervention(M=53.80) compared to before the intervention(M=42.83)(Z=-2.703, p=.007). The application of manual stretching led to a statistically significant increase in right dorsiflexion 5 weeks after the intervention(M=15.40) compared to before the intervention(M=9.36)(Z=-2.814, p=.005). The right plantar flexion exhibited a statistically significant increase 5 weeks after the intervention(M=55.80) compared to before the intervention(M=43.66)(Z=-2.803, p=.005). The left dorsiflexion showed a statistically significant increase 5 weeks after the intervention(M=16.60) compared to before the intervention(M=9.60)(Z=-2.668, p=.008). The left plantar flexion showed a statistically significant increase 5 weeks after the intervention(M=56.40) compared to before the intervention(M=40.02)(Z=-2.805, p=.005)(Table 3).

Table 2. Test of homogeneity between the two groups

	Rt DF M±SD	Rt PF M±SD	Rt DF M±SD	Rt PF M±SD
FBS	11.30±4.692	43.02±8.691	10.06±5.118	42.83±9.632
MS	9.36±5.403	43.66±9.293	9.60±7.011	40.02±5.832
Z	-.916	-.076	-.190	-.455
P	.359	.939	.850	.649

FBS: Footboard stretching, MS: Manual stretching, DF: Dorsiflexion, PF: Plantar flexion

Table 3. A comparison before and after the experiment according to the two interventions (Unit : Angle)

			FBS			MS		
			M±SD	Z	P	M±SD	Z	P
Rt	DF	pre	11.30±4.692	−2.618	.009	9.36±5.403	−2.814	.005
		post	14.50±3.689			15.40±5.929		
	PF	pre	43.02±8.691	−2.666	.008	43.66±9.293	−2.803	.005
		post	50.00±6.254			55.80±4.638		
Lt	DF	pre	10.06±5.118	−2.805	.005	9.60±7.011	−2.668	.008
		post	14.20±4.392			16.60±5.461		
	PF	pre	42.83±9.632	−2.703	.007	40.02±5.832	−2.805	.005
		post	53.80±5.789			56.40±7.336		

FBS: Footboard stretching, MS: Manual stretching, DF: Dorsiflexion, PF: Plantar flexion

Table 4. An analysis of the the impace of the two interventions on the ROM (Unit : Index)

	Rt DFM±SD	Rt PFM±SD	Lt DFM±SD	Lt PFM±SD
FBS	3.20±2.25093	6.98±6.30287	4.14±1.92596	10.97±8.43327
MS	6.04±1.77526	12.14±5.69390	7.00±4.73756	16.38±5.19718
Z	−2.945	−1.778	−1.364	−1.780
P	.003	.075	.173	.075

FBS: Footboard stretching, MS: Manual stretching, DF: Dorsiflexion, PF: Plantar flexion

To determine changes in the ROM between the interventions, the degrees of changes in the ROM following the application of footboard stretching and manual stretching to the soleus were analyzed using the Mann−Whitney U test, based on non−parametric statistics. The results showed a statistically significant increase only in right dorsiflexion in the thatmanual stretching group(M=6.04) compared to that of the footboard stretching group(M=3.20)($p<0.05$). No statistically significant higher increases were observed in either group in the right plantar flexion(p=.075), left dorsiflexion (p=.173), and left plantar flexion(p=.075)(Table 4).

DISCUSSION

The ROM changes according to the location of joints, shape of articular surfaces, and flexibility of muscles(21), and it is also closely related to power, agility, and muscle strength. Therefore, it is a major variable in the ability to perform exercises. When the ROM is small, power and skills cannot be properly used, even when the subject has a high degree of muscle strength and skills (5). When standing up from a sitting position, the soleus is the last muscle to be activated . When ankle dorsiflexion is switched to plantar flexion, this soleus muscle controls the speed of knee extension and maintains a stable standing posture by acting on the front and back of the ankle and the knee(22,23). Therefore, it plays an important role in movementphysical activities of daily life.

In this study, both this 5 week footboard stretching and manual stretching that were applied to the soleus5 increased the ROM of the ankle joint, which was statistically significant ($p<.01$). These increases in flexibility are in line with the results of studies by Hwang(24), Baek(25), McNair and Stanley(26), and Wang(27), in which changes in the flexibility of the soleus according to the types of stretching were examined and the results of studies by Kim(5) and Kim(28), in which changes in flexibility of the hamstring were examined.

In the present study, footboard stretching generated a higher level of flexibility in the ankle joint than manual stretching. The largest increases were 7.00° in left dorsiflexion and 16.38° in left plantar flexion. Thus, the ROM of the left ankle increased more than the ROM of the right ankle. Park(29) studied the effects of a 6-week program of different types of stretching on the ROM of elderly people. In that study, in terms of changes in the ROM of the ankle joint, the dorsiflexion ROM decreased in both the control group and static-active stretching group. The ROM increased in the light-resistance stretching group and proprioceptive neuromuscular facilitation(PNF) stretching group. The largest increase in the ROM (2.22°) was recorded in the PNF stretching group. Although plantar flexion increased in all four groups, the largest increase(4.11°). occurred in the static-active stretching group. The findings of that study are in accordance with the results of the present study, in which the manual stretching group showed larger increases in ROM and a pronounced increase in plantar flexion ROM.

Baek(25) examined the effects of stretching training on the flexibility of the soleus. In that study, the subjects were divided into four groups (control, footboard stretching, contract relax, and contract relax antagonist contract), and they performed stretching exercises for 7 weeks. In the control group, the ankle ROM from dorsiflexion to plantar flexion decreased by 0.32°. In the footboard stretching, contract relax, and contract-relax antagonist contract groups, the ankle ROM from dorsiflexion to plantar flexion showed increases of 5.11°, 8.63°, and 10.13°, respectively. Hwang(24) examined changes in the ROM of knee and ankle joints after the application of static and dynamic footboard stretching for 8 weeks and did not observe large differences between the two interventions($p>.05$). However, the static stretching resulted in relatively larger changes than dynamic stretching in the ROM of both joints. The studies of McNair and Stanley(26) and Wang(27) also showed that static stretching led to larger increases in the ROM of the ankle joint.

The above results suggest that any type of stretching can help improve flexibility by increasing the lengths of the muscles, tendons, and ligaments around joints. However, in the present study, although both footboard stretching and manual stretching, which areis performed in the physical therapy practice, helped increase flexibility, manual stretching was more effective.

The superiority of manual stretching may be explained by the physical therapist applying relatively inconsistent force and momentary force during the exercise

CONCLUSIONS

This study involved 20 men and women in their 20s who were divided them into a footboard stretching group(n=10) and manual stretching group(n=10) to apply passive stretching. After applying stretching to the soleus for 5 weeks, a comparative analysis of the ROM of the ankle joint was performed, and the following results were derived.

Both footboard stretching and manual stretching were effective in enhancing the flexibility of the soleus with statistical significance, and showed increases in the ROM of the ankle joint. However, manual stretching led to statistically significant higher increases. In particular, the manual stretching group showed a statistically significant higher increase in right ankle joint dorsiflexion when compared to that of the footboard stretching group($p<.01$).

REFERENCES

1. Kim HT. The effect of time, duration, and timing of static stretching on flexibility of juvenile's hamstring muscle. Unpublished doctoral dissertation Kookmin University 2001.
2. Ong CN, Chia SE, Jeyaratnam J, Tan KC. Musculoskeletal disorders among operators of visual display terminals. Scand J Work Environ Health 1995;21(1):60-64.
3. Alter MJ.Science of flexibility 3rd ed. Champaign, IL: Human Kinetics 2004.
4. Anderson B, Burke ER. scientific medical and practical aspects of stretching. Clin Sports Med 1991;10(1):63-86.
5. Kim TH. The effect of stretching type on muscular fitness. Unpublished doctoral dissertation Incheon National University 2001.
6. Taylor DC, Dalton JD, Seaber AV, Garrett WE Jr. Viscoelastic properties of muscle-tendon units: the biomechanical effects of stretching. Am J Sport Med 1990;18(3):300-309.

7. Liemonhn W. Factors related to hamstring strains. J Sports Med Phys Fitness 1978;15(1): 168-171.
8. Worrel TW, Perrin DH, Gansneder B, Gieckj J. Comparison of isokinetic strength and flexibility measures between hamstring injures and non-injured athletes. J Orthop Sports Phys Ther. 1991;13(3):118-125.
9. Areg JC. Hamstring injuries: proposed etiological factors, prevention and treatment. Sports Med 1985;2(1):21-33.
10. Witvtouw EN, Mahieu L, Danneels. Stretching and injury prevention. Sports Med 2004;34(7): 443-449.
11. Lee HH, Yook DW, Ko WS, Park YS, Lee HW. The effects of static stretching and Evjenth-Hamberg stretching on range of motion of knee joint. Phys Ther Korea 2005;12(2):37-43.
12. Lee GS. Effect of pain reduction and flexibility on regular stretching exercise for frequent computer user with musculoskeletal disorder. Unpublished doctoral dissertation Kookmin National University 2006.
13. Altan L, Bingol U, Aykac M, Yurtkuran M. Investigation of the effect of GaAs laser therapy on cervical myofascial pain syndrome. Rheumatol Int 2005;25(1):23-27.
14. Anderson JC. Stretching before and after exercise: effect on muscle soreness and injury risk. Athl Train 2005;40(3):218-220.
15. Kim HC. The effect to be influenced upon job satisfaction and productivity by gymnastic activity of working place. Unpublished Master's dissertation Kyunghee University 2003.
16. Cho JM. The effects of ballistic stretching on flexibility & isokinetic muscular functions. J Sport Leisure Studies 2013;52(2):653-662.
17. Gajdosik RL. Effect of static stretching on the maximal length and resistance to passive stretch of short hamstring muscle. J Sports Phys Ther 1991;14(6):260-255.
18. Michael KS, Joseph JD, Teddy WW. Effect of pelvic position and stretching method on hamstring muscle flexibility. Med Sci Sports Exerc 1992;24(12):1383-1389.
19. William DB, Jean MI, Michelle B. Effect of static stretch and dynamic range of motion training on flexibility of the hamstring muscle. J Sport Phys Ther 1998;27(4):295-300.
20. Akagi R, Takahashi H. Effect of a 5 week static stretching program on hardness of the gastrocnemius muscle. Scand J Med Sci Sports 2013; 24(6):950-957.
21. Johns RJ, Wright V. Relative importance of various tissues in joint stiffness. J Appl Physiol 1962; 17(5):824-828.
22. Chang WN. The effects of antagonistic activity of soleus muscle in paretic limb on leg muscle activation patterns during sit to stand movement in stroke. Unpublished doctoral dissertation Yongin University 2010.
23. Cheng PT, Chen CL, Wong MK, Hong WH. Leg muscle activation patterns sit stand movements in stroke patients. Am J Phys Med Rehabil 2004; 83(1):10-16.
24. Hwang DK. The effects of stretching types on Judo player's joint working range. Unpublished doctoral dissertation Yongin University 2014.
25. Paek HJ. Effects of stretching techniques on the flexibility of soleus Muscle. Unpublished doctoral dissertation Ewha Womans University 2014.
26. McNair PJ, Stanley SN. Effect of passive stretching and jogging on the series elastic muscle stiffness and range of motion of the ankle joint. Br J Sports Med 1996;30(4):313-317.
27. Wang W. The effects of static stretching versus dynamic stretching on lower extremity joint range of motion, static balance, and dynamic balance. Unpublished doctoral dissertation Wisconsin Milwaukee University 2013.
28. Kim KH. Comparison of duration of maintained hamstring flexibility after static, dynamic and PNF stretching protocol. Unpublished doctoral dissertation Chosun University 2002.
29. Park HS. The effects of three stretching techniques on the range of motion in elders. The Unpublished doctoral dissertation Ewha Womans University 2001.