Original Article

JER

http://dx.doi.org/10.12965/jer.130013

Journal of Exercise Rehabilitation 2013;9(2):292-297

The effects of ankle mobilization and active stretching on the difference of weight-bearing distribution, low back pain and flexibility in pronated-foots subjects

Ki-Seok Yoon[1], Seong-Doo Park[2,*]

[1]Yeolin Orthopedic Surgery, Cheonan, Korea
[2]Graduated School of Physical Therapy, Daejeon University, Daejeon, Korea

The purpose of this study was designed to analyze the effects mobilization and active stretching on the difference of weight-bearing distribution, low back pain, and flexibility in pronated-foot subjects. The subjects of this study were 16 chronic low back pain patients. They were randomly divided into the control and experimental group. The experimental group had used the model of ankle mobilization and calf muscle active stretching three times per week, for 4 weeks. The control group did same method without an ankle mobilization. The range of flexion and extension motion of the lumbar vertebrae and low back pain degree and difference of weight-bearing were measured before and after the experiment. The model of ankle mobilization and calf muscle stretching of pronated-foot significantly improved the range of flexion and extension motion of the vertebrae. And the visual analogue scale and distribution of weight-bearing were decreased in both of two groups. In other word, the exercise of this study showed that the model of ankle mobilization and calf muscle stretching of pronated-foot had positive effects on improving the range of flexion and extension motion of the vertebrae. The calf muscle stretching was easy and it is effective in therapy that patients by themselves and helped to recover the balance of the vertebrae to combine ankle mobilization and muscle stretching.

Keywords: Low back pain, Mobilization, Muscle stretching exercise, Pronated-foot

INTRODUCTION

Low back pain (LBP) is the common symptom of the lumbar region that more than 80 percent of people experience in their lifetime (Wheeler, 1995). Causes of this symptom are various, but the damage in the soft tissues of body trunk and the weakening of muscle strength are known as the main cause (Fordyce et al., 1986). Especially, it would be difficult to treat the symptom entirely if the essential corrections of bad routinely habit are not accomplished since it expedite its recurrence (Cailliet, 1988). The causes of LBP are various, but the damage in the soft tissues of body trunk and the weakening of muscle strength are the main cause (Fordyce et al., 1986). Brantingham et al. (2006) said foot and lumbar region are functionally connected through the kinetic chain of lower limbs.

Subtalar joint is located between ankle and calcaneal that its front/middle/back side is separated (Hamill and Knutzen, 1965). It moves through a single axis and forms pronation and supination. When subtalar joint is moving from the supination, foot introverts around ankle and then plantarflexion occurs (Lattanza et al., 1988) whereas calcaneal extroverts that dorsiflexion occurs when ankle joint moves from pronation in terms of nonweight-bearing (Wright et al., 1964). However, the pronation of subtalar joint extrovert calcaneal and also the plantar flexion occurs simultaneously. Also, the movement of lower limbs introvert in a horizontal line when weight is bored (Magee, 1997; Root et al., 1997; Tiberio, 1987).

The common mechanical problem of excessive pronated foot

*Corresponding author: Seong-Doo Park
Graduated School of Physical Therapy, Daejeon University, 62 Daehak-ro, Dong-gu, Daejeon 300-716, Korea
Tel: +82-10-9215-2051, Fax: +82-63-540-5161, E-mail: psdbye@hanmail.net
Received: February 27, 2013/ Revised: March 16, 2013/ Accepted: April 1, 2013

includes the posture problem of the waist, hip joint, knee, and excessive extroversion (2-3 degrees) of calcaneal (Valmassy, 1996). Also, the fact that pronated foot limits the dorsiflexion of distal interphalangeal joint is the problem (Munteanu and Bassed, 2006). Pronated foot does not cause problem of the foot itself but disturb the overall dispersion of force due to spinal imbalance including lower limbs.

Bolz and Davies (1982) reported that the muscle strength of shorted foot is lower than the longed one by using various forms of equipment. The imbalance of pelvis must be normalized during the rehabilitation program in order to improve the athletic performance of players. Among studies of the previous researchers, the recovery of shorted foot affects people's body positively.

Among various methods that can be applied to pronated foot, active stretching is one of the stretching types which can be performed independently by patient's thorough education and instructed training. It maintain or increase the joints working range, so that this type of stretching is good for the home exercising program while it can be effective/efficient self-management method against various musculoskeletal disability and nerve root disability other than treating pronated foot (Kisner and Colby, 2002). Also, mobilization of joint is performed by passive joint-angle motor mechanics; it improves the working range of joint and reduces the pain (Kotoulas, 2002).

Although the direct treatment of lumbar region is important, ankle strategy is needed in order to correct the spinal imbalance which takes crucial role in walking and supporting. As a result, this research was proceeded at the thought of aligning foot in a line in order to maintain spinal balance, and combining active therapy with the passive one would be effective in back pain. The premise of this research is that the local therapy of ankle can be used in treating the whole body as the previous researches. The mobilization of ankle affects the alignment of lumbar region at its flexibility that it helps in treating back pain, also there would be change made in the difference of weight bearing of upper/lower limbs through active stretching. The purpose of this research is to provide self-exercising program using active stretching and minimizing back pain through the mobilization of ankle.

MATERIALS AND METHODS

Experimental subjects

Subjects of this study are 24 people who were diagnosed with the chronic LBP from the orthopedist and were acknowledged as pronated-foot since their navicular has dropped more than 10 mm which were revealed from the navicular drop test. For three groups of no treatment, active stretching of triceps muscle, and combination of the mobilization of ankle and active stretching, each eight people were assigned to participate to the 4-week study. However, those with the experience of lower limb surgery, lumbar region surgery due to slipped desk and spinal stenosis, and patients with rheumatic or nerve system problem were excluded. Chronic LBP patients with the attack time more than six months ago were targeted in this study and physical characteristics and age of each group are the following (Table 1).

Table 1. Characteristics of subjects

Group	Age (yr)	Height (cm)	Weight (kg)	Short foot
ASG (n=8)	35.50±9.47	167.82±7.91	62.50±10.74	Left : 5 Right : 3
AS+MOG (n=8)	166.83±12.15	162.25±4.71	67.63±14.36	Left : 3 Right : 5
CG (n=8)	67.23±10.07	64.88±9.12	67.88±6.08	Left : 4 Right : 4

ASG, Active stretching group; MOG, Mobilization group; CG, Control group; M±SD, mean±standard deviation.

Trunk flexion test (TFT)

Measuring is completed at the behind of trunk while the object is standing upright. This examination is used to measure the degree of curve in thoracolumbar, and can simply be examined with a tapeline. Measuring the motion range of joint is done by measuring the close distance of anatomical point of proximal limb and that of distal limb. When the object is standing upright, examiner should mark the location of C7 and then instruct them to slowly bend their waist forward. When the object have bended their waist, the distance of S1 is marked. Assistant researcher is dealing with the measuring in order to improve the reliability of the examination, also measuring is done for the three times and its average value becomes the measured value (Lee et al., 1988).

Trunk extension test (TET)

Objects hold their hands backward and spread tiptoes about 45 cm, so that proper lying position would set. Then, bend upper body backward so that chin would be lifted as high as possible. The height is measured from mat to chin (Hwang et al., 2007). Assistance researcher is dealing with the measuring in order to improve the reliability of the examination, also the measuring is done for the three times, and its average value becomes the measured value.

Visual analogue scale (VAS)

VAS is used in measuring in order to grasp the criterion of pain. It is an index showing patient's subjective pain, and it is commonly used in measuring the strength of pain in study. By drawing the 10cm line, left side would be the area of zero where pain does not exist, and right side would be the area where the strength of pain gets stronger. Grade is measured from zero to ten, and it was applied by measuring the marking point of patients into distance (Scott and Huskisson, 1979).

Weight-bearing distribution (WBD)

Put the two scales side by side on a flat ground, and measure by instructing objects to put their lower limbs on the scale. Objects were instructed to look at an assigned point and put their arms on both sides of the trunk in order to exclude the factors which could affect their weight. When weight is fixed, it was regarded as its side of value. This process was repeated for three times and its average value was set as a measured value as well. The scale was controlled in every process of measuring, and weight was measured before therapy and after the therapy, four weeks later (Kim, 2001).

Active stretching of ankle

Lying position was used as an active stretching in this study. Objects were instructed to dorsiflexion the ankle joint up to maximum motor range, and maintain this posture for ten seconds and then ten seconds of relaxing. Perform ten time times one set, three sets in a day, and three times of exercising in a week, four weeks in total. It is based on the suggestion of Delorme (1946) that the effective number of repetitive exercise is ten times.

The mobilization of ankle

Objects lie on the table, their ankle joint is in the state of plantar flexion and they should maintain the neutral posture and fix the point of patient's one-third distal point of lower legs. Grab the both sides of malleus with the thumb and second finger and slowly go downward to the point where the neck part of ankle is touched. Vibrate for about 30 sec while carrying out, introversion towards horizontal line and extroversion towards the opposite direction (Moon, 2004). After carrying out for 30 sec, relax for the same amount of time and that is one set. Ten times would be one set in this study, three sets in a day and three times of carrying out this exercise in a week, four weeks in total.

Data analysis

The program, Window SPSS 12.0, was used when the data was statistically analyzed. All the variables calculated average value and standard deviation, Shapiro-wilk was carried out to test the normality of each dependent variable, and one way ANOVA was used to compare between groups. Schaffe method was used as the posteriori test. Statistical significance was $P<0.05$.

RESULTS

Change made in the curve of the lumbar region

Active stretching group has changed 58.65±4.96 cm into 61.12±4.23 cm after exercise, mobilization of ankle plus active stretching group has changed 58.06±3.37 cm into 63.60±3.86 cm which show statistical significance ($P<0.05$). However, the comparison group has changed 57.43±3.51 cm into 57.65±2.95 cm which does not show statistical significance ($P>0.05$) (Table 2).

Change made in the lumbar extension

Active stretching group has changed 18.73±7.21 cm into 20.18±7.37 cm after exercise; mobilization of ankle plus active stretching group has changed 17.23±4.50 cm into 20.37±5.06 cm which show statistical significance ($P<0.05$). However, the comparison group has changed 10.93±2.12 cm into 11.81±2.46 cm which does not show statistical significance ($P>0.05$) (Table 2).

The effect of mobilization of the ankle joint against pronated foot and active stretching of triceps muscle has over the visual analogue scale

Active stretching group has changed 6.25±0.71 into 5.68±0.82 after exercise; mobilization of ankle plus active stretching group

Table 2. Pre-post comparison of TFT, TET, VAS, and WBD

Group	Variable	Pre	Post	t
ASG	FTF (cm)	58.65±4.96	61.12±4.23	-5.506[a)]
	TET (cm)	18.78±7.21	20.18±7.37	-3.690[a)]
	VAS (point)	6.25±0.71	5.68±0.8247	4.016[a)]
	WBD (kg)	4.50±1.69	2.50±1.28	3.685[a)]
AS+MOG	FTF (cm)	58.06±3.37	63.60±3.86	-5.559[a)]
	TET (cm)	17.23±4.50	20.37±5.06	-5.695[a)]
	VAS (point)	6.62±1.02	3.37±1.21	9.539[a)]
	WBD (kg)	6.62±1.68	2.18±1.13	6.967[a)]
CG	FTF (cm)	57.43±3.51	57.65±2.95	-0.548
	TET (cm)	10.93±2.12	11.81±2.46	-2.263
	VAS (point)	6.87±1.80	6.43±1.74	1.594
	WBD (kg)	5.37±1.68	5.50±1.60	-0.424

ASG, Active stretching group; MOG, Mobilization group; CG, Control group; TFT, Trunk flexion test; TET, Trunk extension test; VAS, Visual analogue scale; WBD, Weight bearing distribution; M±SD, Mean±standard deviation. [a)]$P<0.05$.

http://dx.doi.org/10.12965/jer.130013

Table 3. Between groups on the analysis of variance

Variable	Group	Sum of square	df	F	*P*
TFT (cm)	Between group	114.27	2	15.934	0.00[a]
	Within group	75.30	21		
	Total	189.57	23		
TET (cm)	Between group	22.43	2	7.046	0.05[a]
	Within group	33.43	21		
	Total	55.87	23		
VAS (point)	Between group	40.39	2	35.892	0.00[a]
	Within group	11.81	21		
	Total	52.21	23		
WBD (kg)	Between group	83.39	2	19.859	0.00[a]
	Within group	44.09	21		
	Total	127.49	23		

TFT, Trunk flexion test; TET, Trunk extension test; VAS, Visual analogue scale; WBD, Weight bearing distribution. [a]$P<0.05$.

has changed 6.62±1.02 cm into 3.37±1.21 cm which show statistical significance. However, the comparison group has changed 6.87±1.80 into 6.43±1.74 which does not show statistical significance ($P>0.05$) (Table 2).

Change made in the weight bearing of both lower limbs due to the mobilization of ankle joint against pronated -foot and active stretching of triceps muscle

Active stretching group has changed 4.50±1.69 kg into 2.50±1.28 kg after exercise; mobilization of ankle plus active stretching group has changed 6.62±1.68 kg into 2.18±1.13 kg which show statistical significance ($P<0.05$). However, the comparison group has changed 5.37±1.68 kg into 5.50±1.60 kg which does not show statistical significance.

The comparison between the effects of therapeutic method

In terms of lumbar region flexion ($F=15.934$; $P<0.05$), retro flexion ($F=7.046$; $P<0.05$), pain ($F=35.892$; $P<0.05$) and weight bearing ($F=19.859$; $P<0.05$), significant difference existed between these parts (Table 3). The result of posteriori test using Scheffe method shows that significant difference does not exist in terms of lumber region flexion, retro flexion and pain. However, the mobilization of ankle plus active stretching group shows significant difference when compared with the active stretching group and comparison group. All three groups show significant difference in terms of weight bearing ($P<0.05$) (Table 4).

Table 4. Post hoc comparison of TFT, TET, VAS, and WBD

Variable	(I) Group	(J) Group	Mean difference (I-J)	*P*
TFT (cm)	ASG	ASG + MOG	3.062	0.01[a]
		CG	-2.22	0.08
	ASG + MOG	ASG	-3.062	0.01[a]
		CG	-5.325	0.00[a]
	CG	ASG	2.262	0.08
		ASG + MOG	5.325	0.00[a]
TET (cm)	ASG	ASG + MOG	1.737	0.04[a]
		CG	-0.525	0.71
	ASG + MOG	ASG	-1.737	0.04[a]
		CG	-2.262	0.01[a]
	CG	ASG	0.525	0.71
		ASG + MOG	2.262	0.01[a]
VAS (point)	ASG	ASG + MOG	-2.687	0.00[a]
		CG	0.125	0.95
	ASG + MOG	ASG	2.687	0.00[a]
		ASG + MOG	2.812	0.00[a]
	CG	ASG	-0.125	0.95
		ASG + MOG	-2.812	0.00[a]
WBD (kg)	ASG	ASG + MOG	-2.437	0.01[a]
		CG	2.125	0.03[a]
	ASG + MOG	ASG	2.437	0.01[a]
		CG	4.562	0.00[a]
	CG	ASG	-2.125	0.03[a]
		ASG + MOG	-4.562	0.00[a]

TFT, Trunk flexion test; TET, Trunk extension test; VAS, Visual analogue scale; WBD, Weight bearing distribution; ASG, Active stretching group; MOG, Mobilization group; CG, Control group. [a]$P<0.05$.

DISCUSSION

The first step to evaluate posture and balance control is to evaluate musculoskeletal system. Especially the weakening of the ligaments around ankle and the limitations of its working range induces bigger compensatory action of hip joint and trunk in order to correct the imbalance. If the working range of ankle joint is reduced, another working pattern is needed in order to compensate its balance that the decrease of posture control limits the working range of the joint. Also, movement of hip joint and trunk are induced as its compensatory action (Horak, 1987). Posture is related with the various arrangements of a body that it is the result of the combination of all the joints that is working during a specific exercise. Joints are mutually connected that the functional change of a joint and structure instantly causes the functional change of a connected joint (Norkin and Levangie, 1992). Among muscles of the lower limbs, weakening of the dorsiflexion of ankle disturbs

its balance (Brown et al., 1998).

From this study, researchers tries to study the balance through the weight bearing difference of the both lower limbs by carrying out the mobilization of joint against pronated foot which is the main strategy of balance. Also, the chain effect of joints over the lumbar region is grasped (Cherkin et al., 1994). Trunk flexion method is used to measure the flexibility of the lumbar region and hamstring in the examination of physical strength. They reason why flexibility is chosen as the lower factor of physical strength is based on the fact that certain amount of flexibility reduces the occurrence of back pain. Paul (2001) asserts that the connective tissue of our body is one unit in terms of structure and function, and knee is connected when hamstring is attached to hipbone. This is connected to the sacrotuberous ligament so that it could be attached to the sacral, and boundary layer is attached from upper cervical spine to sacral. This research agrees with the perspective that a body is a connected organism since all the joints are connected.

Hyung et al. (2009) measured the muscle activity and dynamic balance of ankle muscles when the mobilization of joint and active stretching were carried out three times a week, four weeks in total to the 17 member of experimental group with a pronated foot. As a result, both the muscle activity and dynamic balance increased in the peroneal muscle which was showed during the electromyogram (EMG). Pronated foot reduces the stability and motility that foot should manage itself that it induces the malfunction of connected muscles, and these malfunction develop into the instability of ankle joints when it becomes chronic. Biomechanical change is induced due to the abnormal physical sense, abnormal ability to maintain center of gravity and abnormal weight supporting ability, and functional disability occurs since this change affects the muscles and balance of a body. Although the slightest difference exists in measuring tools and methods, the weight bearing effect of the both lower limbs are similar to the result that it showed more decreased effect when the combination of active stretching and mobilization of the ankle joint are carried out in this research. Choi (2001) asserted that the spinal deformity is related with the specific part of a foot or the foot itself and the lesion of a foot are related with the spinal deformity reversely. Also, lordosis, one of the forms of a spinal deformity, is related with a foot in this context. Since the flexibility of lumbar region and pain control are affected when mobilization of joint and active stretching are carried out and this supports the argument of this research. Lee (2005) studied the effect of the improvement made in the working range of ankle joint has over the walk and balance of elders, and found that his improvement increases the walking speed and steps. Hence, she asserted that it helps the walk of elders, improves balance when mobilization of joint is carried out, and prevents fall by increasing the working range of dorsiflexion muscle which is the cause for the fall of elders. Tropp and Odenrick (1988) asserted that there is a link between ankle joint and hip joint targeting those with the functional instability of ankle, and his research is similar with the result of this research that mobilization of ankle joint and active stretching influences balance.

Foot is said to be the second heart. Foot is important that proper walking or proper forms of a foot aligns our body, maintains the balance between right and left, and prevents the damage of muscles. The flexibility of lumbar region, pain, and the weight bearing difference of both lower limbs was studied in this research. According to the previous research, dorsiflexion of the ankle joint affects the flexibility of lumbar region. Also, it was found that the flexibility of lumbar region is affected when similar active stretching was carried out. However, this research is based on the theory of Moon (2004) that the combination of active exercise and passive exercise, mobilization of ankle joint, could be the most effective one. As a result, statistical significance did not existed between the group of active stretching and combination group in terms of lumbar region flexion, but it existed in terms of pain and weight bearing difference of both lower limbs; it can be said even more effective. Based on this result, it supports the theory that a body is a connected organism. Back pain can be treated or prevented by maintaining the proper balance and flexibility of lumbar region, also home exercising program and specified therapeutic methods should be studied in the future.

This research was conducted to find out the effect of active stretching and mobilization of ankle joint has over the change occurring in the lumbar region and the weight bearing difference of both lower limbs.

Active stretching of the triceps muscle against pronated foot affect the flexibility of lumbar region, pain, and weight bearing difference while the combination of active stretching and mobilization of ankle joint affect all three factors. Also, combination group showed more influence in terms of lumbar region flexion, pain and weight bearing difference of the both lower limbs when the comparison were made between comparison group and experimental group. It shows that the combining method improves pain and flexibility in more significant extent.

http://dx.doi.org/10.12965/jer.130013

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

Bolz S, Davies GJ. Leg length differences and correlation with total leg strength. J Orthop Sports Phys Ther 1984;6:123-129.

Brantingham JW, Lee Gilbert J, Shaik J, Globe G. Sagittal plane blockage of the foot, ankle and hallux and foot alignment-prevalence and association with low back pain. J Chiropr Med 2006;5:123-127.

Brown M, Sinacore DR, Host HH. The relationship of strength to function in the older adult. J Gerontol A Biol Sci Med Sci 1995;50:55-59.

Cailliet R. low back pain syndrome. Philadelphia, FA Davis; 1988.

Cherkin DC, Deyo RA, Loeser JD, Bush T, Waddell G. An international comparison of back surgery rates. Spine 1994;19:1201-1206.

Choi HY. Study on the relationship between scoliosis and foot. Unpublished Master Thesis. Daegu University; 2001.

Delorme TL. Heavy resistance exercises. Arch Phys Med Rehabil 1946;27:607-630.

Fordyce WE, Brockway JA, Bergman JA, Spengler D. Acute back pain: a control-group comparison of behavioral vs traditional management methods. J Behav Med 1986;9:127-140.

Hamill J, Knutzen KM. Biomechanical basis of human movement. Boltimore, Wilson & Wilkins; 1965.

Hwang YT, Yoo GT, Lee MY, Park LJ. The effect of heat therapy in stretching exercise on lumbar flexibility. J Rehabil Sci 2007;25:103-114.

Hyung IH, Kim HS, Lee GC. The effect of muscle activities and dynamic balance ability with mobilization and active exercise on pronation foot. Korean Soc Sport Leis Stud 2009;37:1023-1032.

Horak FB. Clinical measurement of postural control in adults. Phys Ther 1987;67:1881-1885.

Kim SY. Comparison of the difference of weight-bearing distribution between subjects with low back pain and healthy subjects. Phys Ther Korean 2001;8:1-8

Kisner C, Colby LA. Therapeutic Exercise. Philadelphia, FA Davis; 2002.

Kotoulas M. The use and misuse of the terms manipulation and mobilization in the literature establishing their efficacy in the treatment of lumbar spine disordes. Phys Ther Canada 2002;4:53-61.

Lattanza L, Gray GW, Kantner RM. Closed versus open kinematic chain measurements of subtalar joint eversion: implications for clinical practice. J Orthop Sports Phys Ther 1988;9:310-314.

Lee JH, Ham YU, Jang SG. Measure and evaluation. In: Anonymous Seoul: University Public, 1988:111-112.

Lee SE. Effects of increasing ankle range of motion program on ambulation and balance for the elderly with balance disorder. Phys Ther Korea 2005;12:28-36.

Magee DJ. Orthopedic physical therapy. Phiadelphia, WB Saunders; 1997.

Moon SE. General coordinative manipulation. 1st ed. Seoul: Jeongdam Media, 2004.

Munteanu SE, Bassed AD. Effect of foot posture and inverted foot orthoses on hallux dorsiflexion. J Am Podiatr Med Assoc 2006;96:32-37.

Norkin CC, Levangie PK. Joint structure and function: A comprehensive analysis. Philadelphia, FA Davis; 1992.

Paul RL. The primary respiratory mechanism beyond the craniospinal axis. Ame Acad Ostheo 2001;1:24-34.

Root ML, Orien WP, Weed JH. Normal and abnormal function of the foot, clinical biomechanics. Los Angeles: Clinical Biomechanics; 1997.

Scott J, Huskisson EC. Vertical or horizontal visual analogue scales. Ann Rheum Dis 1979;38:560.

Tiberio D. The effect of excessive subtalar joint pronation on patellofemoral mechanics: a theoretical model. J Orthop Sports Phys Ther 1987;9:160-165.

Tropp H, Odenrick P. Postural control in single-limb stance. J Orthop Res 1988;6:833-839.

Valmassy R. Clinical Biomechanics of the Lower Extremities. St. Louis, Mosby; 1998.

Wheeler AH. Diagnosis and management of low back pain and sciatica. Am Fam Physician 1995;52:1333-1341, 1347-1348.

Wright DG, Desai SM, Henderson WH. Action of the subtalar and ankle-joint complex during the stance phase of walking. J Bone Joint Surg Am 1964;46:361-382.