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The Effects of Ankle Strengthening Exercise and Toe Taping Walk Training to Lower Body Exercise Function

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발목강화운동과 무지테이핑 걷기훈련이 하체운동기능에 미치는 영향

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Abstract This study aimed to verify the effects of a 4-week program of ankle-strengthening exercise and toe-taping walk exercise on the basic lower body strength and walking to examine the benefits of the two exercises. The subjects involved 30 women in their 20s enrolled in university A. The subjects were equally divided into three groups – ankle-strengthening exercise group, toe-taping walk exercise group, and control group. The subjects were instructed to massage and do ankle-strengthening exercises using a towel, massage ball, and CRT, for 60 minutes, 3 times a week. They also taped their hallux valgus using a kinesiology tape and walked for 20 minutes with white tape applied. To sum up, the 4-week ankle-strengthening exercise and toe-taping walk exercise were identified to have a partial statistical significance on the basic lower body strength (muscular strength, power, and balance) and walking (length of gait line, plantar pressure, and COP) of women in their 20s. Therefore, the study confirmed the effects of ankle-strengthening exercises and toe-taping walk exercise on the lower body exercise function, and it is considered that further studies should be conducted on more various effects of the exercises by subdividing them into different pain locations and orthomechanic findings.

Key Words : Ankle strengthening exercise, Toe taping, Walk exercise, Lower body exercise function, Gait test

요 약 본 연구는 발목강화운동과 무지테이핑 걷기훈련 운동을 통하여 얻어지는 효과를 알아보기 위하여 4주간 발목강화운동과 무지테이핑 걷기운동이 하체기초체력과 보행에 미치는 영향을 검증하고자 하였다. 이를 위해 A대학에 재학중인 20대 여성 30명을 무선 선정하여 발목강화운동군, 무지테이핑 걷기운동군, 통제군 각 10명으로 선정하였다. 본 실험으로는 주 3회 60분간 4주간 수건 및 마사지볼, CRT를 이용한 마사지와 발목강화운동을 실시하였으며, 또한, 화이트 테이프 처치 후 20분간 걷기 및 키네지오 테이프를 이용한 무지외반 테이핑을 실시하였다. 위의 내용을 종합해본다면 4주간의 발목강화운동과 무지테이핑 걷기운동은 20대 여성의 하체기초체력(근력, 순발력, 평형성)과 보행(활보장, 족저압, COP)에는 통계적으로 일부 유의미한 효과를 나타내었다. 따라서, 본 연구에서 실시한 발목강화운동과 무지테이핑 걷기운동이 하체 운동기능에 대한 효과를 확인하였으며, 후속연구에서는 통증위치별, 정형외과적 소견별로 나누어 보다 다양한 효과를 알아보는 연구가 필요할 것이라고 사료된다.

키워드 : 발목강화운동, 무지 테이핑, 걷기훈련, 하체운동기능, 보행검사

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1. Introduction

Ankle joints play a critical role in sensory feedback, balance, and body posture in daily life or during regular exercise. Hence, limitations and loss of movement brought about by deteriorated ankle joint functions cause significant damage to the musculoskeletal system. According to a study, limited range of motion (ROM), dynamic stability, or loss of dynamic stability increases the risk of lower extremity wounds and walking disorders. Also, it was investigated that the damages and accompanying symptoms of ankle sprain cause a great deal of time loss, reduced physical activity, and poorer quality of life, especially in the US where more than 25,000 ankle sprain cases are reported daily[1].

Toe-bending is one of the most frequently used foot movements. It takes place in a broad scope of physical movement such as walking or running. In particular, it was reported that toe-bending plays a highly important role in activities where the body is pushed against with the feet, such as jumping[2]. The feet are a crucial part of supporting and exercising body weight. Most toe injuries occur in the first toe. Kim & Kim & Sung[3] stated that it is because the stress line of weight shift passes through the thumb side when walking or running, placing a great deal of burden on it.

The foot and ankle joints are complexly connected to each other in the lower limbs. They do not cause functional disorders solely they affect the proximal area, distal area, or both at the same time[4]. The most common injury of the foot and ankle is the injury to the lateral ligament of the ankle[5], and foot deformity not only affects the feet, but also affects the alignment of the ankles, knees, legs, pelvis, and spine. Deformed feet are forced to exercise in an unstable condition, which causes excessive and abnormal movement of the joints as well as fatigue, damage, and pain, leading to structural issues in the body; multiple studies are being done on body postures[6].

In the past, it has been considered a virtue to make outcomes while persevering on injuries. Unconditional rest has been a must after surgical treatment. However, with the rapidly growing interest in health in the modern era, terms such as healing, health, clinic, rehabilitation, and therapy have become much more common in daily life[7]. The best representatives of alternative therapies are massages and taping.

Massages are widely used for fatigue recovery and injury prevention. When a specific part of the body is hurt, human beings unconsciously press, stroke, or rub the part based on the instinct to protect themselves. As such, massage, a kind of human adaptation to nature, promotes the circulation of blood and lymph fluid in the skin and muscles, and enhances motor functions by facilitating metabolism in the body[8]. There is much research that studied pain reduction by a foot massage. According to Um[9], sports massage and foot reflexology massage posed a significant influence on the reduction of low back pain. Also, Kalron[10] stated that walking is closely related to fatigue, and walking tests are used as an appropriate mediator variable.

Taping has been utilized as a medium to support the explosive exercise abilities of professional athletes and to prevent sports injuries. Non-athletes use taping as a way to alleviate acute or chronic muscular and joint pain as it is easy to perform with no considerable side effects[11]. Kim[12] stated that taping of the femoral area was identified to have a significant increase in the records of the rectus abdominis, rectus femoris, vastus medialis, and vastus lateral muscles when it was in the leg extension motion, which is an open chain exercise.

There has been a sufficient amount of research on ankle joint fatigue depending on the foot type as well as inversion and eversion, passive treatment, the association between the foot and the ankle, and the direct effectiveness of taping and massage on the treated spot. However, there is only a little complex research on indirect effectiveness.

Hence, this study aims to support therapies and injury treatment where passive and active foot treatments ease foot pain. The findings provide various ways to improve exercise abilities by examining the effects of the 4-week ankle-strengthening exercise and toe-taping walk exercise on the lower body exercise functions of women in their 20s with foot pain and orthopedic findings.

2. Research Method

2.1 Subject of Study

The subjects involved women in their 20s enrolled in university A in Gyeonggi-do Province, who report foot pain in daily life and have orthopedic findings. The subjects were provided with a full explanation prior to the experiment, and those who gave consent for voluntary participation were selected. Thirty of them were equally divided into three groups: ankle-strengthening exercise group, toe-taping walk exercise group, and control group. The physical characteristics are as shown in Table 1.

Table 1. The physical characteristic of subjects

Group	N	Age (yr)	Height (cm)	Weight (kg)
A	10	21.00 ±0.67	158.68 ±4.60	55.27 ±6.72
B	10	21.00 ±2.16	160.16 ±4.39	53.04 ±3.00
C	10	21.40 ±1.58	160.24 ±6.41	56.72 ±7.65

A: Ankle Strengthening Exercise Group
B: Toe Taping Walk Exercise Group
C: Control Group

2.2 Experimental Method and Treatment

2.2.1 Body composition test

BSM330 Bio-space was used to measure height and body weight.

2.2.2 Gait test

The pre-measurement was performed a day before the start of the experiment. The post-measurement was conducted a day after the end of the 4-week program. The subjects were told to take off their shoes. Both pre-and post-measurement were carried out without massage and taping treatment. Zebis (Germany) was used to measure stride length, plantar pressure, and COP (length of gait line, single support line, and ant/post position).

2.2.3 Basic lower body strength test

The pre-measurement was performed a day before the start of the experiment. The post-measurement was conducted a day after the end of the 4-week program. The subjects were told to take off their shoes. Both pre and post-measurement were carried out without massage and taping treatment. Three items were measured: 30° leg extension, standing high jump, and Single-leg balance (eyes closed).

2.2.3.1 30° Leg extension

BS-LS (bio-space) was used to measure 30° leg extension. The muscle extension (isotonic contraction), which is one of the lower body function tests, was measured by fixing it at 30° based on the knee joint. Here, the femoral muscle strength was measured, referring to Yoo[13] measurement.

2.2.3.2 Standing high jump

BS-FS (bio-space) was used to measure the standing high jump. The subjects were instructed to stand with their feet on the ground and jump vertically to the sound of the buzzer. The records were measured in centimeters. Standing high jump is one of the power items of the lower body exercise function test.

2.2.3.3 Single-leg balance (eyes closed)

BS-FS (bio-space) was used to measure single-leg balance. The subjects stood on one foot that they felt comfortable with and bent another in the air. Then, they were instructed to close their eyes to the sound of the buzzer, and the time, until their foot fell or moved, was measured in seconds. Single-leg

balance is one of the balance items.

2.2.4 Taping for the toe-taping walk exercise

Taping methods were divided into two types. The subjects were told to place their first toe on top of the second toe, which was then fixed with an M-tape. Then, they walked on the treadmill for 20 minutes, after which were treated with a kinesiology tape (Nitto, Japan). It was removed after a 40-minute walk in daily life conditions. A total of 1-hour walk was carried out to an extent where the subjects did not feel any pain, walking at their own pace. Taping was performed by one physical therapist with more than 3 years of experience in the floor exercise room of university A. Taping methods of Jeong & Hong & Son[8] and Perrin[14] were referred.

2.2.5 Ankle-strengthening exercise and massage

The ankle-strengthening exercise was carried out by one physical therapist with more than 3 years of experience and one expert. Four types of exercise were performed for 35 minutes: 5 minutes of calf stretching by holding onto the wall, hanging a towel on the foot, pulling and pushing for 5 minutes each, 5 minutes of grabbing and extending the toes, and 10 minutes of calf stretching by holding onto the wall again. Kneading was applied for the massage. A massage ball was used for 10 minutes and the myofascial relaxation tool (CRT, Korea) was used to massage the soles for 15 minutes. The duration and treatment method of the ankle-strengthening exercise and massage were referred to Jung[15] & Perrin[14].

2.3 Data Processing

The findings of the study were processed through the SPSS/PC+ Ver 18.0 for Windows. Descriptive statistics were used to obtain the mean (M) and standard deviation (SD) of the items of each group. Also, two-way repeated ANOVA was performed to verify the effects of the 4-week ankle-strengthening exercise and toe-taping walk training, and the significance level was set at $p<.05$.

3. Results

The study divided the subjects (aged in their 20s) into three groups: ankle-strengthening exercise group (A), toe-taping walk exercise group (B), and control group (C). The effects of the 4-week ankle-strengthening exercise and toe-taping walk training on the lower body exercise functions were as identified below.

3.1 Changes in the basic physical fitness of the lower body

3.1.1 Change in Leg muscular strength 30°

To investigate the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on leg muscle strength at 30°, the average and two-way repeated ANOVA analysis results for each group are shown in Table 2 to Table 3. Looking at the average of the ankle strengthening exercise group for each muscle strength L 30°, it was 25.96±2.55kg in before exercise and 26.81±26.81 after 4 weeks, and the toe taping walking exercise group was 24.78±5.97kg in before exercise and 29.54±1.78kg in 4 weeks, and the control group was 23.74±3.83kg in before exercise and 23.64±4.51kg after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in time ($F=5.190$, $p<.05$). However, there was no significant difference in the interaction effect of time × group.

The mean of the ankle strengthening exercise group for angular muscle strength R 30° was 33.94±4.47 kg in before exercise and 31.57±6.20kg after 4 weeks, The toe taping walking exercise group was 29.07±6.15 kg in before exercise and 33.65±3.06kg in 4 weeks, and the control group was 28.50±4.85kg in before exercise and 27.90±3.73kg in 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect ($F=4.735$, $p<.05$).

Table 2. The change of muscular strength L 30°

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
muscular strength L 30°(kg)	pre (0 Week)	A	10	25.86±2.55	Group	131.450	2	65.725	2.701	.085
		B	10	24.78±5.97	error	656.927	27	24.331		
		C	10	23.74±3.83	Period	52.453	1	52.453	5.190	.031*
	post (4 Weeks)	A	10	26.81±5.26	Group*period	65.397	2	32.699	3.236	.055
		B	10	29.54±1.78						
		C	10	23.64±4.51	error	272.855	27	10.106		

Table 3. The change of muscular strength R 30°

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
muscular strength R 30°(kg)	pre (0 Week)	A	10	33.94±4.47	Group	217.864	2	108.93	3.204	.056
		B	10	29.07±6.15	error	917.993	27	34.000		
		C	10	28.50±4.85	Period	4.320	1	4.32	.314	.580
	post (4 Weeks)	A	10	31.57±6.20	Group*period	130.446	2	65.223	4.735	.017*
		B	10	33.65±3.06						
		C	10	27.90±3.73	error	371.918	27	13.775		

A: Ankle Strengthening Exercise Group B: Toe Taping Walk Exercise Group C: Control Group *p<.05

3.1.2 Change of the in-Place Standing High Jump

The average and two-way repeated ANOVA analysis results for each group are shown in Table 4 to investigate the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on in-place standing high jump in lower body exercise function. Looking at the average of the ankle strengthening exercise group for in-place standing high jump, it was 19.24±4.66cm before exercise and 20.54±4.00cm after 4 weeks, toe taping walking exercise group was 20.71±2.15 kg in before exercise and 23.14±3.61 cm after 4 weeks, and the control group showed 21.64±4.63cm before exercise and 20.82±3.85cm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect ($F=4.326$, $p<.05$) and also a significant difference in time ($F=4.485$, $p<.05$).

3.1.3 Change of the Single-leg balance (eyes closed)

To investigate the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on lower body exercise functions on the single-leg balance (eyes closed), the average and two-way repeated ANOVA analysis results for each

Table 4. The change of the in-place standing high jump

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
in-Place Standing High Jump (cm)	pre (0 Week)	A	10	19.24±4.66	Group	42.799	2	21.40	.780	.486
		B	10	20.71±2.15	error	740.363	27	27.421		
		C	10	21.64±4.63	Period	14.114	1	14.114	4.485	.044*
	post (4 Weeks)	A	10	20.54±4.00	Group*period	27.223	2	13.612	4.326	.023*
		B	10	23.14±3.61						
		C	10	20.82±3.85	error	84.959	27	3.147		

Table 5. The change of the single-leg balance (eyes closed)

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Single-leg balance (eyes closed) (sec)	pre (0 Week)	A	10	16.10±15.96	Group	6215.433	2	3107.717	4.042	.029*
		B	10	31.00±34.85	error	20760.650	27	768.913		
		C	10	11.8±9.739	Period	1782.150	1	1782.150	3.576	.069
	post (4 Weeks)	A	10	53.30±37.12	Group*period	5191.900	2	2595.950	5.209	.012*
		B	10	28.10±28.21						
		C	10	10.20±7.92	error	13454.450	27			

A: Ankle Strengthening Exercise Group B: Toe Taping Walk Exercise Group C: Control Group *p<.05

group are Table 5.

Looking at the average of the ankle strengthening exercise group for the single-leg balance (eyes closed), 19.24±4.66kg in before exercise and 20.54±4.00kg in 4 weeks, The toe taping walking exercise group was 20.71±2.15kg in before exercise and 23.14±3.61kg in 4 weeks, and the control group was 21.64±4.63kg in before exercise and 20.82 ±3.85kg in 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=4.326, p<.05) and also a significant difference in the time (F=4.485 p<.05).

3.2 Changes in the gait

The average and two-way repeated ANOVA analysis results for each group are shown in Table 6 to Table 10 examine the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on gait.

3.2.1 Changes in stride length

Looking at the average of the ankle strengthening exercise group for stride length was 100.10±12.23 cm in before exercise and 103.60±8.57cm in 4 weeks, and the toe taping walking exercise group was 99.90±9.38cm in before exercise and 106.50 ±6.04 kg in 4 weeks, and the control group was 100.40±18.27cm in before exercise and 100.40 ±18.27cm in 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=54.517, p<.05) and a significant difference in the time (F=15.589, p<.001).

3.2.2 Changes in plantar pressure

To investigate the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on plantar pressure in gait, the average and two-way repeated ANOVA analysis results for each group were compared in table 7 to Table 10.

Table 6. The change of the stride length

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
stride length (cm)	pre (0 Week)	A	10	100.10±12.23	Group	78.433	2	39.217	.120	.888
		B	10	99.90±9.38	error	8854.050	27	327.928		
		C	10	100.40±18.27	Period	170.017	1	170.017	15.589	.001***
	post (4 Weeks)	A	10	103.60±8.57	Group*period	109.033	2	54.517	5.085	.013*
		B	10	106.50±6.04						
		C	10	100.40±18.27	error	289.450	27	10.720		

Table 7. The change of the plantar pressure-left/anterior

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
plantar pressure-left/ anterior (N)	pre (0 Week)	A	10	508.70±70.79	Group	9988.233	2	4994.117	.778	.465
		B	10	496.70±32.80	error	171130.500	27	6338.167		
		C	10	527.20±67.26	Period	493.067	1	493.067	1.868	.183
	post (4 Weeks)	A	10	531.40±66.54	Group*period	2166.233	2	1083.117	4.103	.028*
		B	10	494.80±33.03						
		C	10	523.60±60.62	error	7127.700	27	263.989		

Table 8. The change of the plantar pressure-left/posterior

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
plantar pressure-left/ posterior (N)	pre (0 Week)	A	10	374.00±61.21	Group	2470.000	2	1235.000	.214	.809
		B	10	346.20±49.56	error	155692.400	27	5766.385		
		C	10	372.80±58.86	Period	1995.267	1	1995.267	2.585	.120
	post (4 Weeks)	A	10	384.20±63.01	Group*period	6064.993	2	3032.467	3.928	.032*
		B	10	383.00±16.65						
		C	10	360.40±75.48	error	20842.800	27	771.956		

Table 9. The change of the plantar pressure-right/anterior

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
plantar pressure-right/ anterior (N)	pre (0 Week)	A	10	519.60±107.88	Group	11671.900	2	5835.950	.382	.686
		B	10	499.80±61.49	error	412350.450	27	15272.239		
		C	10	510.20±111.29	Period	7370.417	1	7370.417	13.516	.001***
	post (4 Weeks)	A	10	560.80±84.96	Group*period	5903.233	2	2951.617	5.413	.011*
		B	10	530.30±30.62						
		C	10	505.00±107.18	error	14722.850	27	545.291		

Table 10. The change of the plantar pressure-right/posterior

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
plantar pressure-right/ posterior (N)	pre (0 Week)	A	10	385.50±73.66	Group	48888.70	2	24444.35	3.304	.052
		B	10	355.60±58.20	error	199754.300	27	7398.307		
		C	10	340.80±50.83	Period	2432.067	1	2432.067	2.432	.130
	post (4 Weeks)	A	10	411.20±64.06	Group*period	9816.633	2	4908.317	4.909	.015*
		B	10	391.10±68.02						
		C	10	317.80±71.17	error	26996.300	27	999.863		

A: Ankle Strengthening Exercise Group B: Toe Taping Walk Exercise Group C: Control Group *p<.05, ***p<.001

Looking at the mean of the ankle strengthening exercise group for plantar pressure-left/anterior was 508.70±70.79N in before exercise, 531.40 ±66.54N in 4 weeks, and the toe taping walking exercise group was 496.70±32.80N in before exercise, 494.80±33.03N in 4 weeks, and the control group was 527.20±67.26N in before exercise and 523.60 ±60.62N after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time × group interaction effect (F=1083.117, p<.05).

Looking at the mean of the ankle strengthening exercise group for plantar pressure-left/posterior was 374.00±61.21N in before exercise and 384.20 ±63.01N in 4 weeks, and the toe taping walking exercise group was 346.20±49.56N in before exercise and 383.00±16.65N in 4 weeks, and the control group was 372.80±58.86N in before exercise and 360.40±75.48N after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=3032.467, p<.05).

Looking at the average of the ankle strengthening exercise group for plantar pressure-right/anterior was 519.00±107.88N before exercise and 560.80 ±84.96N after 4 weeks, and the toe taping walking exercise group was 499.80±61.49N before exercise and 530.30±30.62N after 4 weeks and the control group was 510.20±111.29N before exercise and 505.00±107.18N after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=2951.617, p<.05) and a significant difference between periods (F=7370.417, p<.01).

Looking at the average of the ankle strengthening exercise group for plantar pressure-right/posterior, it was 385.50±73.66N before exercise and 411.20 ±64.06N after 4 weeks and the toe taping walking exercise group was 355.60±58.20N before exercise and 391.10±68.02N after 4 weeks and the control group was 340.80±50.83N before exercise and 317.80±71.17N after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=9816.633, p<.05).

3.2.3 Change in COP(Center of pressure)

The average and two-way repeated ANOVA analysis results for each group are shown in Table 11 to Table 15 to examine the effect of 4 weeks of ankle strengthening exercise and toe taping walking exercise on COP in gait.

Looking at the average of the ankle strengthening exercise group for the length of gait line-L was

Table 11. The change of the length of gait line-L

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Length of gait line - L (mm)	pre (0 Week)	A	10	198.65±10.17	Group	670.221	2	335.110	.940	.403
		B	10	203.35±9.60	error	9624.135	27	356.449		
		C	10	203.22±18.23	Period	.486	1	.486	.057	.813
	post (4 Weeks)	A	10	195.80±12.03	Group*period	98.269	2	49.134	5.793	.008**
		B	10	206.76±6.28						
		C	10	203.20±19.55	error	228.995	27	8.481		

Table 12. The change of the length of gait line-R

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Length of gait line - R (mm)	pre (0 Week)	A	10	197.07±10.42	Group	831.769	2	415.885	1.524	.236
		B	10	192.36±11.34	error	7365.854	27	272.809		
		C	10	206.48±14.24	Period	339.864	1	339.864	16.841	.001***
	post (4 Weeks)	A	10	200.33±10.90	Group*period	368.524	2	184.262	9.131	.001***
		B	10	203.80±9.80						
		C	10	206.06±14.94	error	554.872	27	20.180		

Table 13. The change of the singles support line-L

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Singles support line - L (mm)	pre (0 Week)	A	10	112.21±10.62	Group	399.865	2	199.933	.931	.406
		B	10	117.34±8.47	error	5798.642	27	214.765		
		C	10	111.32±14.80	Period	58.017	1	58.017	2.431	.131
	post (4 Weeks)	A	10	118.55±6.01	Group*period	143.701	2	71.851	3.011	.066
		B	10	117.28±5.49						
		C	10	110.94±15.67	error	644.272	27	23.862		

Table 14. The change of the singles support line-R

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Singles support line - R (mm)	pre (0 Week)	A	10	115.54±10.34	Group	346.856	2	173.428	1.066	.359
		B	10	112.20±10.83	error	4394.079	27	162.744		
		C	10	111.86±9.65	Period	169.680	1	169.680	9.829	.004**
	post (4 Weeks)	A	10	118.47±7.93	Group*period	182.884	2	91.442	5.297	.011*
		B	10	120.04±6.53						
		C	10	111.18±10.80	error	466.130	27	17.264		

Table 15. The change of the Ant/post position

Factor	Period	Group	N	M±SD	Group	SS	df	MS	F	p
Ant/post position (mm)	pre (0 Week)	A	10	136.47±6.74	Group	37.453	2	18.727	.444	.646
		B	10	135.58±1.97	error	1138.313	27	42.160		
		C	10	133.62±4.56	Period	42.673	1	42.673	4.535	0.42*
	post (4 Weeks)	A	10	134.10±6.25	Group*period	10.308	2	5.154	.548	.585
		B	10	133.41±4.65						
		C	10	133.10±4.86	error	254.049	27	9.409		

A: Ankle Strengthening Exercise Group B: Toe Taping Walk Exercise Group C: Control Group *p<.05, **p<.01, ***p<.001

198.65±10.17mm before exercise and 195.80±12.03 mm after 4 weeks and the toe taping walking exercise group was 203.35±9.60mm before exercise and 206.76±6.28mm after 4 weeks and the control group showed 203.22±18.23mm before exercise and 203.20±19.55mm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect (F=5.793, p<.01).

Looking at the average of the ankle strengthening

exercise group for Length of gait line –R was 197.07 ±10.42mm before exercise and 200.33±10.90mm after 4 weeks and the toe taping walking exercise group was 192.36±11.34mm before exercise and 203.80±9.80mm after 4 weeks and the control group showed 206.06±14.94mm before exercise and 206.06±14.94mm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the interaction effect between time×group ($F=9.131$, $p<.01$), and a significant difference was also found in time ($F=16.841$, $p<.001$).

Looking at the average of the ankle strengthening exercise group for Singles support line–L was 112.21 ±10.62mm before exercise and 118.55±6.01mm after 4 weeks and the toe taping walking exercise group was 117.34±8.47mm before exercise and 117.28±5.49mm after 4 weeks and the control group was 111.32±14.80mm before exercise and 110.94±15.67mm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was no significant difference in the time×group interaction effect.

Looking at the average of the ankle strengthening exercise group for Singles support line–R was 115.54 ±10.34mm before exercise and 118.47±7.93mm after 4 weeks and the toe taping walking exercise group was 112.20±10.83mm before exercise and 120.04±6.53mm after 4 weeks and the control group was 111.86±9.65mm before exercise and 111.18±10.80mm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect ($F=5.297$, $p<.05$) and also a significant difference in time ($F=9.829$, $p<.01$).

Looking at the average of the ankle strengthening exercise group for the ant/post position was 136.47 ±6.74mm before exercise and 134.10±6.25mm after 4 weeks and the toe taping walking exercise group was 135.58±1.97mm before exercise and 133.41±4.65mm after 4 weeks and the control group was 133.62±4.56mm before exercise and 133.10±4.86mm after 4 weeks. As a result of the two-way repeated ANOVA analysis, there was a significant difference in the time×group interaction effect ($F=4.535$, $p<.05$).

4. Discussion

This study aimed to examine the effects of the 4-week ankle-strengthening exercise and toe-taping walk training on the lower body exercise functions of women in their 20s as well as the effects of passive and active training, and suggest treatment programs for people with foot pain. The subjects involved 30 women in their 20s with foot pain with orthopedic findings. During the 4-week program, they were divided into three groups-ankle-strengthening exercise group, toe-taping walk training group, and control group. The exercises' effects on lower body exercise functions were identified, and the following discusses the findings.

4.1 Changes in the basic lower body strength functions

For the basic lower body strength test, 30° leg extension, standing high jump, and single-leg balance (eyes closed) were performed. Each item was selected based on the results of the preceding research. Muscular strength, power, and balance were measured. According to the study by Han & Kong[16], where the changes in the basic physical strength after walking forward and backward on a treadmill were observed, the walk-forward group showed the effects of the standing high jump and single-leg balance (eyes closed) training. Also, as a result of middle-aged women carrying out sling exercises and sports massages, it was reported that they were effective in improving functional performance in the daily life of middle-aged women with chronic back pain[17]. In sum, it can be concluded that walking training and massage influence lower-body exercise functions. In general, physical strength is the ability of muscles to perform tasks

during exercises. Among different types of physical strength, the basic strength is measured by muscular strength, muscular endurance, agility, and power. Balance has been recently added to the measured items. The basic physical fitness test is widely used in exercise programs as a means to identify its meaning.

As a result of the study, 30° leg extension, standing high jump, and single-leg balance (eyes closed) showed a significant difference in the three groups ankle-strengthening exercise group, toe-taping walk training group, and control group. An interactive effect was found between 30° leg extension, standing high jump, and single-leg balance (eyes closed).

In the toe-taping walk training group, a significant difference was found in 30° leg extension L after the 4-week program, while 30° leg extension R showed a significant difference compared to the control group. As the standing high jump was observed to show a significant difference, it can be confirmed that the toe-taping walk training group had more significant effects than the ankle-strengthening exercise group. Yet, 30° leg extension L showed a significant difference between periods in the toe-taping walk training group. It is necessary to examine the dominance and non-dominance of the lower body and conduct detailed research in the future. In terms of single-leg balance (eyes closed), the standard deviation (SD) of the ankle-strengthening exercise group and the toe-taping walk training group, except the control group, showed a difference. The results of the non-parametric method showed that SD increased in 9 out of 10 subjects in the ankle-strengthening exercise group, while it increased in 7 out of 10 subjects in the toe-taping walk training group between the pre- and post-measurement.

4.2 Changes in the gait

According to Kim[18], therapeutic taping helped patients with patella osteoarthritis to ease pain during knee extension exercises and on the stairs. Also, Kim & Song[19] stated that the toe-pushing power of the ankle-strengthening exercise group using a balance-training mat showed a greater significant difference. Following are the findings of the study seen through preceding and existing studies.

In terms of period×group, significant differences were found in the ankle-strengthening exercise group, toe-taping walk training group, and control group in items of the stride length, plantar pressure, and length of gait line. Singles support line and ant/post position did not show a significant difference but were identified to have changed between periods.

Regarding stride length, the pre- and post-measurement results did not show a significant difference in groups, but the toe-taping walk training group showed a significant difference in period×group. This implies that the toe-taping walk training posed a more positive effect on the length of the gait line compared to the ankle-strengthening exercise. The length of gait line improvement was greater in the toe-taping walk training group than in the ankle-strengthening exercise group. This is in line with the findings of Lee & Kim & Choi[20], who reported that the orthopedic taping method affects the stance phase and pain while walking. In terms of plantar pressure, a significant difference was found in all items – front side, rear side, left side, and right side, as well as in period×group. However, while the ankle-strengthening exercise group reported a significant difference in the right-rear side with the control group, other sides – right-front, left-front, and left-rear–did not show a significant difference. This implies that while ankle-strengthening exercise and toe-taping walk training have a positive effect on plantar pressure, there is no difference between each exercise. In terms of COP (center of pressure), length of gait line and singles support line–R showed a significant difference in period×group. This means that the duration of the stance phase and swing phase lengthened. It was difficult to conclude that the ankle-strengthening exercise and toe-tap-

ing walk training had statistical significance as the pre- and post-measurements did not show any significant difference. In regards to the length of gait line-R, the toe-taping walk training group showed a significant difference in the pre-measurement compared to the control group. There was no inter-group difference in the post-measurement, but for the inter-period changes in groups, both the ankle-strengthening exercise group and the toe-taping walk training group showed a statistically significant difference. This implies that both the ankle-strengthening exercise group and toe-taping walk training group have positive effects after the 4-week program. In terms of singles support line-R, both the ankle-strengthening exercise group and toe-taping walk training group showed a significant difference. This means that the support area of the right foot has improved in stability.

In sum, ankle-strengthening exercises and toe-taping walk training had positive effects on walking, helping it to improve. Also, as the plantar pressure improved with lengthened stance and swing phases, the power to push the body forward with the first toe with the heel supporting the body has gained strength. It is considered that it was because each subject feels pain in different spots, and the areas were not specifically divided as dominant and non-dominant. Further studies shall examine deeper with a greater number of cases, involving more pain types and orthopedical findings.

5. Conclusion & Suggestion

This study examined the effects of the 4-week ankle-strengthening exercise and toe-taping walk exercise on lower body exercise functions, involving 30 subjects, women in their 20s, with foot pain and orthopedic findings. The findings are as follows:

First, the 4-week ankle-strengthening exercise and toe-taping walk exercise showed a statistically significant difference ($p<.05$) in all items except 30° leg extension among the basic lower body fitness items and 30° leg extension L in standing high jump. They had a positive effect on the strength of the lower extremity.

Second, the 4-week ankle-strengthening exercise and toe-taping walk exercise showed a statistically significant difference ($p<.05$) in period×group in terms of stride length, plantar pressure, and COP (length of gait line, single support line, and ant/post position). The ant/post position also showed a significant difference ($p<.05$), but no significant difference was found in terms of period×group.

To conclude, the ankle-strengthening exercises and toe-taping walk exercise were found to have positive effects on lower body exercise functions. It was difficult to derive a significant difference from between the two exercises. Yet, it is considered that further studies need to analyze the factors and items from a wider angle, and divide them into different pain locations, hallux valgus angles, and foot shapes, to examine the effects in greater detail.

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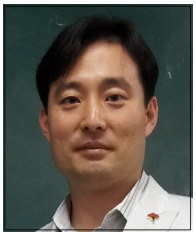

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