

Effect of Taping and Pilates Core Stabilization Exercise on Physical Alignment and Improvement of Genu Recurvatum in Women

Background: More women than men experience genu recurvatum, which can lead to knee pain and arthritis if left unattended. Pilates combined with taping is a suitable rehabilitation method for women with genu recurvatum.

Objectives: To aimed the effect of taping and Pilates stabilization exercise on physical alignment and improvement of genu recurvatum in women with genu recurvatum.

Design: A Randomized controlled trial.

Methods: Twenty-one women were divided into three groups: taping group (back of knee taping and quadriceps femoris taping, n=7), Pilates exercise group (hip, knee and abdominal muscles exercise, n=7), and combined group (taping with pilates exercise, n=7). The measured variables were sagittal plane alignment and back and abdominal muscle, knee flexor and extensor strength.

Results: After the intervention, all sagittal plane alignments were significantly improved in both the Pilates and combined groups. Sagittal plane alignment was significantly improved in the combined group compared with the taping group. Back and abdominal muscle strength were significantly improved in the Pilates and combined groups compared with the taping group. Knee flexor and extensor were significantly improved in the combined group compared with the Pilates group and in the Pilates group compared with the taping group.

Conclusion: Pilates exercise with taping or Pilates exercise alone was effective intervention methods to improve physical alignment and strength in women with genu recurvatum.

Keywords: *Taping; Genu recurvatum; Physical alignment; Pilates exercise; Lower extremity muscle strength*

Sony Lee, MS^a, Bokyoung Kim, PT, Prof., PhD^b, Shinjun Park, PT, Prof., PhD^c, Soonhee Kim, PT, Prof., PhD^d

^aSoneedbodycare, Hwaseong, Republic of Korea;

^bInternational University of Korea, Jinju, Republic of Korea;

^cDepartment of Physical Therapy, Suwon Women's University, Hwaseong, Republic of Korea;

^dDepartment of Physical Therapy, Yongin University, Yongin, Republic of Korea

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Address for correspondence

Soonhee Kim, PT, Prof., PhD

Department of Physical Therapy, Yongin University, 134 Yongindaehak-ro, Cheoin-gu, Yongin-si, Gyeonggi-do, Republic of Korea

Tel:***-****-****

E-mail: shkim2776@nate.com

INTRODUCTION

Genu recurvatum refers to a deformity in the knee joint resulting in the knee bending backward, with over 0° of excessive hyperextension in the knee joint.¹ Genu recurvatum is more common in women than in men,² and if left unattended may lead to knee pain and arthritis.³

Interventions to control genu recurvatum are focused on strengthening the knee extensor. However, there are various causes for genu recurvatum, including weakness of the knee extensor and

flexor, excessive anterior pelvic tilt, decreased lordosis of lumbar spine, deficiency in ankle dorsiflexion, stretched knee ligaments, and proprioceptive disorders.⁴ Thus, an intervention plan to control genu recurvatum should be established based on under-standing flexion of the knee joint and various causes as well as enhancement of knee extensor strength.

Taping of the knee joint can effectively control excessive extension of the knee either in the standing position or during gait. Taping on the knee flexor moves the knee joint forward and controls excessive extension of the knee, thus reducing the knee angle

in the standing position.⁵ Because the tape is cut to fit the body, it can be applied according to an individual's physical characteristics.⁶

The primary cause of genu recurvatum is muscle weakness in the knee joint, whereas a secondary cause is related to weakness of core stability muscles. When the abdominal and iliacus muscles are weakened, hip flexors are predominantly used owing to reciprocal inhibition.⁷ This leads to internal rotation and extension of the femur, which causes extension of the anterior cruciate ligament, resulting in genu recurvatum or knee injury. Therefore, core stabilization exercise is required to strengthen the core stability muscles in order to prevent genu recurvatum and knee injury. Pilates exercise techniques are focused around the abdomen, emphasizing core muscle strength, and are used to improve overall flexibility and health.⁸ Even beginners can easily participate in Pilates exercise, which is beneficial for the musculoskeletal system and is currently used in many areas such as calisthenics, health, and rehabilitation.⁹ In addition, Pilates exercise has positive effects on stabilization of the knee extensor and flexor as well as postural balance.^{10,11}

Despite such preceding studies, there has been no study on the combined effect of taping and Pilates exercise composed of core stabilization exercises on genu recurvatum. To improve various issues that patients with genu recurvatum may experience, intervention should be applied to the knee, and secondary issues should also be addressed through core stabilization. Thus, the present study aimed to investigate the effects of knee taping and Pilates exercise on physical alignment and muscle strength in women with genu recurvatum and to develop new intervention methods for genu recurvatum.

SUBJECTS AND METHODS

Subjects

The present study was performed with 21 women in their 20s to 40s who were visiting S Pilates center in Gyeonggi-do. The selection criteria for the study subjects were as follows: (1) age 20s to 40s, (2) over 0° of extension in the knee joint in a standing position, (3) no knee surgery, (4) no limitation in ankle dorsiflexion range in a standing position, and (5) submission of the informed consent form for the present study. The exclusion criteria were as follows: (1) skin disease, and (2) excessive pain in the knee with 3 or more points on a visual analog scale. The 21 subjects

were randomly divided into three groups with seven subjects each: a taping group with taping intervention, Pilates exercise group with Pilates stabilization exercise intervention, and a combined group with both Pilates stabilization exercise and taping. A website (www.randomization.com) was used for randomization. Pre-evaluation was performed before the intervention, and post-evaluation was carried out after 2 weeks of seven intervention sessions. This study was reviewed and approved by the Institutional Review Board (IRB) of Young-in University (IRB No. 2012-HSR-203-1).

Outcome measures

Anthropometric measurements

To examine the alignment between the knee extension angle and the sagittal plane of the subjects, a body checker (Body Style; Mzen Corp., Seoul, Korea) was used.

To evaluate alignment of the sagittal plane, a side view of subjects in the standing position was imaged from 2 m away. Using the Body Style program (S8.0_ver.1.0), the line of gravity was defined as the line on the images connecting the external acoustic pore, the center of the shoulder joint, the centerline of the knee joint, and the calcaneocuboid joint, which corresponds to the ideal alignment.¹² The regions of the external acoustic pore and the center of the shoulder joint based on the vertically connected line from the calcaneocuboid joint were measured. Regarding the measured values on the sagittal plane (in centimeters), all deviated values are expressed as positive values.

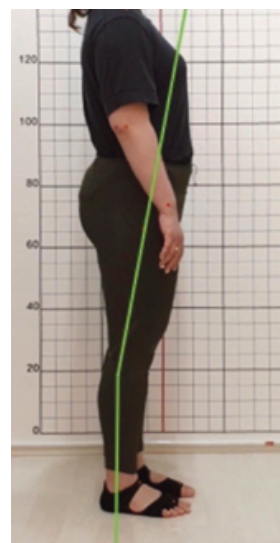


Figure 1. Knee extension angle

Muscle strength measurements

To measure muscle strength, an isometric cable tensiometer (TKK-5402; TAKEI, Japan) and a hand-held dynamometer (Hoggan Health Industries, Salt Lake City, USA) were used. The chain of the tensiometer was adjusted for each subject. Back muscle strength was measured while raising the upper body from tilting to 30° with the handle held using an overhand grip in standing position. Abdominal muscle strength was measured while leaning the upper body forward with holding the grip using an underhand grip. Pulling time was between 3 and 5 seconds, and the mean values of three measurements were used. Knee flexor and extensor strength (in pounds) was measured using manual muscle testing with a hand-held dynamometer.¹² Mean values from three repeated measurements were used as outcomes. To prevent fatigue, subjects were given 3 minutes of rest between measurements.

Interventions

All interventions were carried out in seven sessions for 2 weeks, and taping was replaced once a day. Pilates exercise was performed for 30 minutes per intervention session.

Taping

Regarding the taping intervention, 5-cm-wide kinesiology tape (Kinematics Tex; Healthmade, Korea) was used. Taping was applied on the quadri-

ceps femoris muscle and back of knee taping (popliteal region). For the quadriceps femoris muscle, taping was applied from the anterior superior iliac spine to the tibial tuberosity with the hip and knee joints flexion.¹³ For taping the genu recurvatum, the knee was folded by 10°–15° in the standing position, and then taping was applied from the far 1/3 position of the femur over the knee joint to the 1/3 position of the calf muscle.¹⁴

Pilates exercise

Of the Pilates exercises reported in a previous study,⁸ the exercise focusing on core stabilization was carried out for 30 minutes (Table 1). A trainer with more than 5 years of clinical experience provided instruction for the Pilates exercise.

Data and statistical analysis

Data were analyzed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). General characteristics of subjects were analyzed using descriptive statistics and calculating means and standard deviations. The non-normal distribution was confirmed by Shapiro-Wilk test. The difference between pre- and post-intervention was tested using the Wilcoxon signed-rank test, whereas the Kruskal-Wallis test was used to examine differences among the three groups. The statistical significance level was set to .05. The Mann-Whitney U test was performed as a post hoc test. To control

Table 1. Pilates exercise program

Classification	Exercise	Time
Warm-up	Side thigh massage	2 sets
Hip muscles strengthening (Gluteus maximus and gluteus medius strengthening)	Shoulder bridge	3 sets
	Side leg lift series	3 sets
	Side kicks	3 sets
Abdominis strengthening (Rectus abdominis and transvers abdominis)	Roll up roll down	3 sets
	Rolling like a ball	3 sets
	Spine stretch forward	3 sets
	Roll over	3 sets
	Jackknife	3 sets
Knee muscles strengthening (Hamstring strengthening)	One leg kick	3 sets
	Double leg kick	3 sets

the increase of type 1 errors caused by multiple comparisons, the Bonferroni alpha correction was applied to interpret outcomes.

RESULTS

General characteristics of subjects

The present study included 21 subjects divided into a taping group, Pilates exercise group, and combined group with seven subjects in each group. Their general characteristics are shown in Table 2.

Changes in physical alignment along the sagittal plane depending on the intervention method

The Pilates exercise group and the combined group, but not the taping group, showed significant reductions in all alignment variables of the sagittal plane

after the intervention ($P < .05$), with the combined group showing significantly larger reductions than the taping group ($P < .05$) (Table 3).

Changes in muscle strength depending on the intervention method

The Pilates exercise group and the combined group, but not the taping group, displayed significant increases in all variables of trunk muscle and leg muscle strength after the intervention ($P < .05$). The Pilates exercise group and the combined group showed a significantly higher increase than the taping group ($P < .05$). The combined group had a significantly higher increase in leg muscle strength than the taping group and the Pilates exercise group ($P < .05$), whereas the Pilates exercise group showed a significantly higher increase than the taping group ($P < .05$) (Table 4).

Table 2. General characteristics of the subjects

Classification	TG (n=7)	PG (n=7)	TPG (n=7)	P
Age (years)	33.14 ± 4.18	39.00 ± 2.00	37.00 ± 8.50	.925
Height (cm)	158.54 ± 8.94	160.74 ± 3.33	159.34 ± 3.84	.785
Weight (kg)	55.00 ± 8.16	61.30 ± 10.89	55.70 ± 5.52	.336

M ± SD: mean ± standard deviation

TG: Taping group

PG: Pilates exercise group

TPG: Taping and pilates exercise group

Table 3. Changes in sagittal plane alignment in three groups

Classification		Pre-test	Post-test	Value difference	
Alignment on sagittal plane (cm)	Ear				
		TG	2.33 ± 1.02	2.09 ± 1.04	-.24 ± .56
		PG	1.96 ± 1.05	.57 ± .33 [*]	-1.38 ± 1.19
		TPG	2.99 ± .80	1.17 ± 1.12 [*]	-1.82 ± 1.11 ^a
Shoulder joint		TG	1.78 ± .54	1.64 ± .65	-.14 ± .96
		PG	2.23 ± 1.47	1.23 ± .71 [*]	-1.00 ± .93
		TPG	2.43 ± 1.36	.16 ± .17 [*]	-2.27 ± 1.27 ^a

M ± SD: mean ± standard deviation

^{*}Significant difference pre and post intervention ($P < .05$)

^aTPG is more significantly improve than TG ($P < .05$)

TG: Taping group

PG: Pilates exercise group

TPG: Taping and pilates exercise group

Table 4. Changes in muscle strength in three groups

(M ± SD)

Classification		Pre-test	Post-test	Value difference	
Back muscular (kg)	TG	46.88 ± 11.86	48.19 ± 12.93	1.31 ± 2.16	
	PG	45.55 ± 11.55	52.90 ± 10.87 [†]	7.36 ± 4.22 [‡]	
	TPG	49.54 ± 11.46	58.14 ± 15.33 [‡]	8.59 ± 5.60 [§]	
Abdominal muscular (kg)	TG	40.90 ± 14.93	41.95 ± 15.15	1.05 ± 2.54	
	PG	41.52 ± 9.07	49.06 ± 6.87 [†]	7.45 ± 4.63 [‡]	
	TPG	43.71 ± 16.09	54.83 ± 17.48 [‡]	11.12 ± 7.01 [§]	
Knee flexor (lb)	Right	TG	14.27 ± 4.31	14.70 ± 4.04	.43 ± 1.58
		PG	13.23 ± 1.93	17.47 ± 3.70 [†]	4.24 ± 2.68 [‡]
		TPG	13.92 ± 2.03	23.70 ± 4.62 [‡]	9.78 ± 3.39 ^{§b}
	Left	TG	14.57 ± 4.17	15.14 ± 4.09	.57 ± 1.16
		PG	13.34 ± 2.28	16.80 ± 3.55 [†]	3.46 ± 2.24 [‡]
		TPG	14.43 ± 2.88	23.69 ± 5.15 [‡]	9.25 ± 2.90 ^{§b}
Knee extensor (lb)	Right	TG	16.74 ± 5.16	17.24 ± 4.26	.49 ± 2.28
		PG	15.05 ± 3.16	18.61 ± 3.65 [†]	3.57 ± .82 [‡]
		TPG	15.05 ± 3.64	25.72 ± 6.49 [‡]	10.67 ± 4.62 ^{§b}
	Left	TG	17.71 ± 6.56	18.19 ± 5.51	.48 ± 1.58
		PG	16.32 ± 2.41	19.27 ± 2.26 [†]	2.95 ± .90 [‡]
		TPG	16.16 ± 4.21	26.82 ± 7.04 [‡]	10.66 ± 5.08 ^{§b}

M ± SD: mean ± standard deviation

[†]Significant difference pre and post intervention ($P < .05$)[‡]TPG is more significantly improve than TG ($P < .05$)[§]TPG is more significantly improve than PG ($P < .05$)^{††}PG is more significantly improve than TG ($P < .05$)

TG: Taping group

PG: Pilates exercise group

TPG: Taping and pilates exercise group

DISCUSSION

The present study aimed to investigate the effects of taping and Pilates stabilization exercise on physical alignment and muscle strength in women with genu recurvatum.

The results showed that the combined group with 2 weeks of intensive taping and Pilates stabilization exercise showed a significant improvement in terms of the external acoustic pore position, changes in the center of the shoulder joint, and trunk muscle strength in comparison to the taping-only group. The combined group and Pilates group also showed an improvement in their center of gravity, including changes in the positions of the external acoustic pore and the center of the shoulder joint compared to the

taping group. To maintain the vertical posture of the body through correct alignments, minimal stress should be loaded on joints, and posture should be maintained with minimal muscular activity. A previous study demonstrated the effect of Pilates exercise using a reformer machine on sagittal plane alignment and forward head posture.¹¹ However, Pilates exercise without any tool can induce the participation of various muscles because it is focused on strengthening the core stability muscles.⁸ It is noteworthy that the present study applied Pilates exercise composed of pelvis and trunk control methods for patients with genu recurvatum without using any reformer machine. In addition, the present study applied taping intervention on the popliteus region to prevent excessive extension of the knee, and on the front of

the knee to control the quadriceps femoris muscle. A previous study showed that taping improved knee function, and combining taping with another intervention method for improving knee function was found more effective.¹⁵ These findings are different from the results of this study. Overall, there was no significant difference in the dependent variable between the combined group and the Pilates group. This suggests to women with genu recurvatum that hip, knee, and trunk muscles strength are important to improve genu recurvatum.

The isometric contraction as a measure of back muscle strength and abdominal muscle strength increased in the combined group or pilates group more than in the taping alone group. Pilates exercise in the present study was to improve genu recurvatum by inducing backward tilting of the pelvis through the promotion of core stabilization⁸ and the enhancement of the iliacus muscle. Women with genu recurvatum may have anterior pelvic tilting due to the weakness of the iliacus muscle and compensatory genu recurvatum due to excessive flexion of the hip joint.¹⁶ As the hamstring muscle, a knee flexor, also affects the iliacus muscle, weakness of these muscles aggravates genu recurvatum.¹⁶ Trunk muscle weakness can lead to aggravation of genu recurvatum, so that it seems that enhancement of abdominal muscle strength by Pilates greatly contributed to the improvement in the alignment and balance of trunk muscles after the intervention.

Regarding the intervention for women with genu recurvatum, one should be aware of the benefits of existing Pilates exercise and the importance of taping. It is noteworthy that taping can be applied for rehabilitation together with Pilates exercise. Combined intervention with taping and Pilates can improve physical alignment and genu recurvatum in women with genu recurvatum.

Nonetheless, the present study has some limitations. First, the daily life of subjects was unable to be controlled. In detail, there was neither documentation nor control over individual factors such as shoes that may affect the posture of patients with genu recurvatum, taping removal time, and routine posture and habits. Second, the subjects were recruited from a single center, making it difficult to generalize the results to all women with genu recurvatum. Genu recurvatum also can be caused by neurological damage, congenital causes, or other serious injuries to the musculoskeletal system. As the subjects in the present study were recruited from a Pilates studio and not from hospitals, it is impossible to generalize the results to all patients with genu recurvatum. To

overcome such limitations, future research should be conducted with a larger sample size and multiple evaluations.

CONCLUSION

The present study demonstrated that a combination of taping and Pilates exercise or Pilates exercise alone was an effective intervention to improve physical alignment and muscle strength in women with genu recurvatum. It should be further studied to develop more effective intervention methods to improve knee alignment and proximal muscle strength of women with genu recurvatum through continuous research and various evaluations.

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