J Int Acad Phys Ther Res 2020; 11(4): 2244~2252
ISSN 2092-8475

www.iaptr.org
https://doi.org/10.20540/JIAPTR.2020.11.4.2244

# Effects of a Complex Exercise Program on the Distance between Knees and Balance in Individuals in their 20s with Genu Varum

Background: Thera-Band, Narrow squats, Kinesiology taping helps in the reduction of loading on the knee joints. Despite the fact that the varus knee negatively affects the alignment of the lower extremities, most of the studies have analyzed each independently.
Objectives: To investigate the effects of a complex exercise program consisting of elastic band exercises and squat exercises on the distance between the inner knees and balance in young adults with genu varum.
Design: A cluster randomized controlled trial.
Methods: The complex exercise group performed resistance exercises using an elastic band. The taping group used kinesiology tape on the vastus lateralis and biceps femoris. To select those to be included in the study, we measured the distance between the knees using digital Vernier calipers and to measure the balance ability, we used a balance training system. The data were analyzed with the independent t-test and paired t-test.
Results: The study indicated a significant difference in the distance between the knees between the two groups, but no significant differences in the dynamic balance between the groups. Also, the static balance comparison between the groups according to the intervention method included the trace length, C90 area, C90 angle and velocity. There were no significant differences in the static balance between the groups. In addition, the complex exercise program was more effective than taping.
Conclusion: The results of this study demonstrate that the complex exercise program and taping decrease the between both the knee and increase the balance.

Keywords: *Balance; Complex exercise; Genu varum; Knee; Taping*

**Beomcheol Jeong, PT, PhD[a], Kyungtae Yoo, PT, Prof., PhD[b]**

[a]Noble Care Hospital, Seoul, Republic of Korea
[b]Department of Physical Therapy, Namseoul University, Chunan, Republic of Korea

Received : 04 October 2020
Revised : 15 November 2020
Accepted : 22 November 2020

**Address for correspondence**
Kyungtae Yoo, PT, PhD
Department of Physical Therapy, Namseoul University, 91, Daehak-ro, Seonghwan-eup, Seobuk-gu, Cheonan-si, Chungcheongnam-do, Republic of Korea
Tel: 82-41-580-2530
E-mail: taeyoo88@nsu.ac.kr

## INTRODUCTION

Good posture and a positive aesthetic appearance are desirable traits. The pursuit of external beauty is more than an improvement in external image for young people. In modern times, a social trend has emerged in which an unbalanced body is suspected to be affected by the individual's competence as young people are trying to overcome it.[1] Abnormalities in the legs largely include genu varum and genu valgum. People in Western Europe tend to have genu valgum, and more than 90% of Koreans have genu varum, which is 15% to 20% of the global population with genu varum.[2]

Generally, genu varum describes knee joints that lean outward from the center line from the hip joint to the knee joint, which results in the meniscus taking a half-moon shape.[3] This deformity can reduce the lifespan of the knee joint by causing degenerative changes and flexural deformations, as well as damage to the surrounding tissue of the joint.[4] Through the internal rotation of the femur bone, external rotation of the tibia bone, and pronation of both feet, the space between both knees increases as the joints move away from the gravity line, resulting in compromised static balance.[5]

Diagnostic methods for both genu varum and valgum include the measurement of the angle of the lower limb joints, Q-angle, and distance between the knees. For the lower limb joint, the thigh bone's long axis is approximately 10 degrees away from the tibia (long axis), so the alignment of the normal adult knee joint is 170-175 degrees when viewed in the coronal plane.[6] A method to measure the Q-angle by the femorotibial angle is connecting the center of the patella and the anterior superior iliac spine and shin bone.[7] The method to measure the distance between the knee joints is by gathering both ankles and holding both medial malleoli parallel to each other. Using digital vernier calipers is an important measurement factor for genu varum.[8]

Methods for correcting genu varum include exercise therapy, taping, multilateral lower extremity orthosis, and bracing.[9,10] Among these, resistance bands, such as the Thera band, are rubber bands that are widely used as a tool for rehabilitation in medical sites, such as hospitals, because they are simple, economical, and safe.[11]

Squat exercises are closed kinetic chain exercises in which both feet are shoulder-width apart and the hip joint, knee joint, and ankle joint are flexed in a repetitive motion.[12] This movement increases co-contraction and compression around the joint, increasing proprioceptive sensibility and function.[13] Narrow squats are effective in reducing the distance between the knees; thus, they are suitable for patients with genu varum and have a greater effect than normal squats.[14]

Among the different taping application methods for genu varum, kinesiology taping helps in the reduction of loading on the knee joints.[15] When applied on a flat surface, kinesiology taping provides structural stability[16] and increases balance and the function of proprioceptors when applied to the knee and ankle.[17]

However, despite the fact that the varus knee negatively affects the alignment of the lower extremities, most of the studies have analyzed each independently such as resistance exercises using elastic bands, resistance exercises using squat movements, and stretching exercises for the varus knees, and the interval between knees, Q-angle and gait analysis were conducted. Therefore, the purpose of this study was to analyze the effects of a complex exercise program consisting of elastic band exercises and squat exercises on the distance between the inner knees and balance in young adults with genu varum.

## SUBJECTS AND METHODS

### Subjects

In this study, 20 men and women from N University in Chungnam with genu varum and a knee distance of grade 3 (5.0 cm) or higher were recruited.[7] All participants voluntarily agreed to this study after receiving a thorough explanation of the purpose and methods of this study before participating in the experiment. Those with congenital bone or neuromuscular disorders were excluded from this experiment. This study was approved by the Institutional Bioethics Committee of Namseoul University (NSUIRB-201806-005).

### Measurement Apparatus

Inbody (InBody 720, Biospace, Korea) was used to establish individuals who had congenital disorders. To select those to be included in the study, we measured the distance between the knees using digital Vernier calipers (DC-03A-150, BESTONE, China) and to measure the balance ability, we used a balance training system (BT4, HUR Labs, Finland). In order to conduct this study, the measurement apparatus are as depicted in Table 1.

### Experimental Method

After identifying the participants' physical characteristics, we randomly placed them into two groups: a complex exercise program group and a taping group. Microsoft Excel was utilized to assign participants

**Table 1.** Measurement apparatus

| Field of measurement | Name | Manufacturer | Country |
|---|---|---|---|
| Body composition analyzer | InBody 720 | Biospace | Korea |
| Digital Vernier calipers | DC-03A-150 | BESTONE | China |
| Balance analysis and exercise system | BT4 | HUR Labs | Finland |

into groups using randomly generated numbers. Measurements were made both before and after the 6 week complex exercise program and taping program. The complex exercise group program included 5 minutes of prep exercises and 22 minutes of main exercises. The program was a total of 32 minutes, three times per week, for a total of 6 weeks. For the preparatory exercise and finishing exercises, hip joint adductors and tensor fasciae latae were targeted. For resistance, we used the Thera-Band (The Hygenic Corp., USA) during narrow squat exercises. Experimental method in the complex exercise group is as depicted in Figure 1 and Table 2.

For the taping group, kinesiology taping (3NS Tape, TS, Korea) was used. Taping was applied to the vastus lateralis and biceps femoris muscles, which are directly affected by genu varum. We applied the tape for 3 days a week for a total of 6 weeks.[18] Experimental method in the taping group is as depicted in Figure 2 and Table 3.

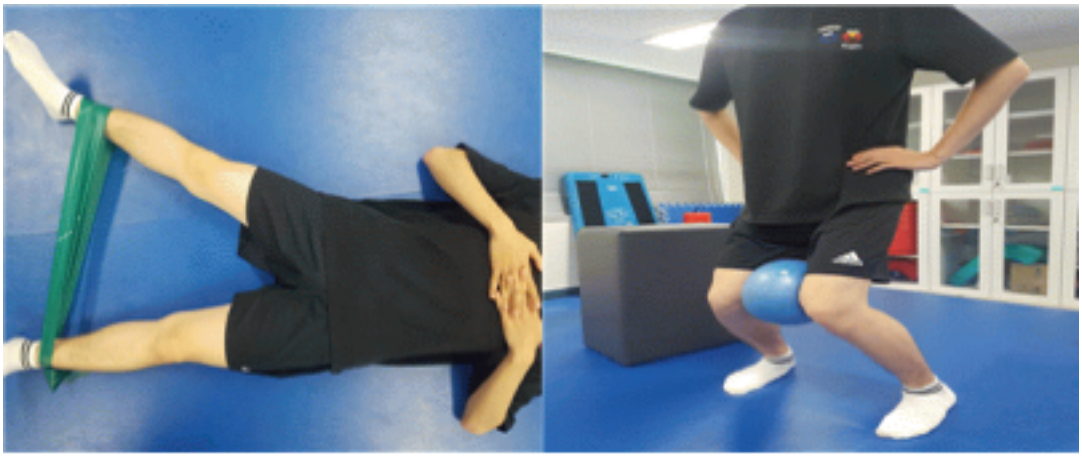

**Figure 1.** Elastic band exercise and narrow squat exercise

**Table 2.** Complex exercises

| Exercise (min.) | | | Program | Frequency |
|---|---|---|---|---|
| Warm up (4) | Stretching | Hip adductor | Sit on the floor with the soles of your feet facing each other, then straighten your waist and slowly press your knees down | 5 times * 3 sets |
| | | Tensor fascia latae | Elongate by supporting yourself with one hand and pushing one leg one step forward, bending the knee and extending the leg beyond the center line and extending the foot | 5 times * 3 sets |
| Main exercises (22) | Complex exercises | Resistive band exercises | Lying down comfortably, fix one end of the band on one ankle, fix the other side on the other ankle, and internally rotate and abduct the lower extremities<br>Perform the movement slowly to allow the angle of the lower limb to move approximately 45 degrees and to strengthen both afferent and efferent contractions | 15 times * 5 sets |
| | | Narrow squats | After spreading both feet shoulder-width apart, with a ball positioned between the knees and the soles of the feet firmly on the floor, lift the thighs up and down until they are level with the floor (90 degrees)<br>Keep the back straight and knees bent for 1 second | 30 times * 3 sets |
| Cool down (4) | Stretching | Hip adductor | Sit on the floor with the soles of your feet facing each other, and then straighten your waist and slowly press your knees down | 5 times * 3 sets |
| | | Tensor fascia latae | With one hand on the support, push one leg one step forward, bend your knee, extend your leg beyond the center line, and stretch your foot outward | 5 times * 3 sets |

**Figure 2.** Vastus lateralis and rectus femoris

To measure the distance between the participants' knees, we had them put both feet together, so that both malleolus bones were together, and measured the space between the tibia and medial condyle.[19]

To measure participants' dynamic balance, we had them remove their shoes and measured the space between both heels, keeping them 2 cm apart and externally rotated 15 degrees with arms at ease on both sides. The participants were required to stand erect and bend as far as they could in four directions (left, right, back, and front) for 8 s each; we then calculated the slope value for each direction.

To measure static balance, we had the participants keep their eyes open and closed for 30 seconds each, while we measured their balance. We had them take their shoes off and measured the space between both heels, keeping them 2 cm apart and externally rotated 15 degrees with arms at ease on both sides.

### Data Analysis

To analyze the results, we used SPSS version 23.0 for Windows. An independent t-test was used to compare the differences in distance between knees and balance between the groups according to the intervention method. A paired t-test was used to compare the differences between the distance between knees and balance within each group. The statistical significance level was set to $\alpha = .05$.

## RESULTS

### General characteristics of the participants

The general characteristics of the participants are presented in Table 4.

**Table 3.** Method of taping

| Muscle | Program |
|---|---|
| Vastus lateralis | 1. In an upright position, extend the knees<br>2. Fix the root of the tape on the vastus lateralis muscle and attach it toward the upper third part of the knee bone<br>3. Next, open the Y part of the tape<br>4. Slowly bend the knees<br>5. When the knees are bent as far as possible, attach the tape, surrounding the inner and outer sides of the knee concave and then fixed |
| Biceps femoris | 1. In the prone position, slightly bend the knee and slightly straighten the hip joint<br>2. Attach the root of the tape to the center of your back thigh<br>3. Among the cracks in the Y-shape, attach the inner sections to the inside of your knee concave while keeping your knee straight<br>4. Among the splits in the Y-shape part of the tape, apply the sections on the side when your knee is slightly bent and then stretched to the maximum |

**Table 4.** General characteristics of the participants

| | Complex exercise group | Taping group | t | *P* |
|---|---|---|---|---|
| Age (years) | 23.4 ± 1.95 | 22.40 ± 1.07 | −2.610 | .173 |
| Height (cm) | 172.20 ± 6.98 | 173.50 ± 12.52 | −.298 | .769 |
| Weight (kg) | 69.10 ± 10.92 | 71.80 ± 14.81 | −.298 | .650 |
| BMI (kg/m$^2$) | 23.29 ± 2.76 | 23.55 ± 3.09 | −.193 | .849 |

### Changes in distance between knees between groups according to the intervention methods

The changes in distance between knees between groups is as shown in Table 5. There was a significant difference in the distance between the knees between the two groups ($P<.05$). The change in the inter-knee distance significantly decreased in both the complex exercise group and the taping group ($P<.05$).

### Changes in dynamic balance according to the intervention methods

The changes in dynamic balance between groups is as shown in Table 6. There was no significant difference in the dynamic balance between the two groups. The dynamic balance significantly decreased in the front and significantly increased in the rear in the complex exercise group. It significantly decreased in the front and significantly increased in the rear in the taping group.

### Changes in static balance according to the intervention methods

The changes in static balance between groups is as shown in Table 7. The results of the static balance comparison between the groups according to the intervention method included the trace length, C90 area, C90 angle std. and velocity. There were no significant differences in the static balance between the groups. As a result of comparing the static balance within the groups, with support of the right foot and the eyes open, the trace length and std. significantly increased in velocity ($P<.05$). When standing on the left foot with both eyes closed, both the complex exercise group and the taping group experienced a significantly decrease in the trace length; the C90 area significantly increased in the complex exercise group; and the std. velocity significantly increased ($P<.05$). With support of the right foot and eyes closed, the trace length and std. velocity significantly decreased ($P<.05$).

**Table 5.** The statistical analysis and comparison of the distance between the knees in each group

| | Group | Pre | Post | t | *P* |
|---|---|---|---|---|---|
| Distance between knees (cm) | Exercise group | 5.18 ± .29 | 4.54 ± .28† | 4.440 | .000* |
| | Taping group | 5.57 ± .47 | 5.46 ± .54† | | |

†Significant differences between pre-test and post-test
*$P<.05$ (= Significant differences between Experimental group and Control group)

**Table 6.** The statistical analysis and comparison of the dynamic balance in each group

| | Group | Pre | Post | t | *P* |
|---|---|---|---|---|---|
| Forward ( ° ) | Exercise group | 6.51 ± 1.58 | 4.59 ± 1.01† | -.377 | .711 |
| | Taping group | 6.27 ± 2.30 | 4.05 ± .54† | | |
| Rearward ( ° ) | Exercise group | 3.00 ± 1.81 | 6.15 ± 1.01† | -.167 | .870 |
| | Taping group | 3.02 ± 1.01 | 6.06 ± .69† | | |
| Leftward ( ° ) | Exercise group | 6.63 ± .89 | 6.86 ± 1.14 | -1.407 | .176 |
| | Taping group | 6.69 ± 1.23 | 6.39 ± 1.14 | | |
| Rightward ( ° ) | Exercise group | 7.06 ± .75 | 6.73 ± 1.11 | .102 | .920 |
| | Taping group | 6.66 ± 1.32 | 6.38 ± 1.02 | | |

†Significant differences between pre-test and post-test
*$P<.05$ (= Significant differences between Experimental group and Control group)

**Table 7.** The statistical analysis and comparison of the static balance in each group

| | | | Group | Pre | Post | t | *P* |
|---|---|---|---|---|---|---|---|
| EO | LT | Trace length (mm) | Exercise group | 1006.99 ± 271.17 | 975.92 ± 335.41 | .362 | .725 |
| | | | Taping group | 984.95 ± 161.02 | 877.65 ± 183.77 | 1.323 | .218 |
| | | C90 area ($mm^2$) | Exercise group | 679.13 ± 367.39 | 877.65 ± 183.77 | .020 | .985 |
| | | | Taping group | 726.81 ± 282.15 | 587.85 ± 284.23 | 1.227 | .251 |
| | | C90 angle ( ° ) | Exercise group | −5.12 ± 79.99 | −6.61 ± 77.18 | .051 | .961 |
| | | | Taping group | −12.97 ± 77.35 | −28.08 ± 79.09 | .390 | .701 |
| | | Velocity (mm/s) | Exercise group | 34.16 ± 8.51 | 32.53 ± 11.18 | .572 | .579 |
| | | | Taping group | 32.83 ± 5.36 | 29.25 ± 6.12 | 1.321 | .218 |
| | RT | Trace length (mm) | Exercise group | 1227.76 ± 411.59 | 990.45 ± 250.42 | 2.063 | .069 |
| | | | Taping group | 1055.11 ± 246.44 | 837.57 ± 257.89 | 3.734 | .005* |
| | | C90 area ($mm^2$) | Exercise group | 1082.66 ± 1205.37 | 774.17 ± 379.59 | .892 | .392 |
| | | | Taping group | 816.47 ± 412.8 | 615.22 ± 415.43 | 1.721 | .118 |
| | | C90 angle ( ° ) | Exercise group | −8.28 ± 79.53 | −3.38 ± 76.45 | −.120 | .903 |
| | | | Taping group | −15.76 ± 82.26 | −.81 ± 79.94 | −.411 | .692 |
| | | Velocity (mm/s) | Exercise group | 40.92 ± 13.71 | 33.01 ± 8.34 | 2.063 | .069 |
| | | | Taping group | 35.17 ± 8.21 | 27.91 ± 8.59 | 3.731 | .005* |
| EC | LT | Trace length (mm) | Exercise group | 1006.99 ± 271.17 | 1913 ± 457.73 | −8.790 | .000* |
| | | | Taping group | 984.95 ± 161.02 | 2015.93 ± 683.87 | −4.923 | .001* |
| | | C90 area ($mm^2$) | Exercise group | 679.13 ± 367.39 | 2227.61 ±1309.25 | −3.721 | .005* |
| | | | Taping group | 726.81 ± 282.15 | 2828.8 ± 3084.3 | −1.270 | .235 |
| | | C90 angle ( ° ) | Exercise group | −5.12 ± 79.99 | −28.44 ± 69.32 | .531 | .604 |
| | | | Taping group | −12.97 ± 77.35 | 26.69 ± 77.75 | −1.274 | .235 |
| | | Velocity (mm/s) | Exercise group | 35.90 ± 8.48 | 61.06 ± 19.36 | −5.071 | .001* |
| | | | Taping group | 32.83 ± 5.36 | 67.19 ± 22.79 | −4.921 | .001* |
| | RT | Trace length (mm) | Exercise group | 2229.22 ± 774.36 | 1708.80 ± 276.90 | 2.452 | .037* |
| | | | Taping group | 2128.31 ± 413.45 | 1846.37 ± 555.88 | 2.031 | .072 |
| | | C90 area ($mm^2$) | Exercise group | 6430.11 ±11665.11 | 1829.58 ± 709.56 | 1.302 | .223 |
| | | | Taping group | 3040.63 ± 2038.74 | 2083.24 ± 749.40 | 1.483 | .171 |
| | | C90 angle ( ° ) | Exercise group | 3.90 ± 79.66 | 9.05 ± 76.04 | −.154 | .883 |
| | | | Taping group | −3.18 ± 77.27 | −16.02 ± 77.84 | .331 | .747 |
| | | Velocity (mm/s) | Exercise group | 74.30 ± 25.81 | 56.96 ± 9.23 | 2.451 | .037* |
| | | | Taping group | 70.94 ± 13.78 | 61.54 ± 18.53 | 2.030 | .072 |

†Significant differences between pre–test and post–test

*$P$<.05 (= Significant differences between Experimental group and Control group)

## DISCUSSION

Misalignments of the knee, such as genu varum, drastically affect the function of the joint and can cause knee loading during sport activity and/or everyday life.[20]

This study analyzed young adults with genu varum who participated in a complex exercise program or underwent kinesiology taping, which affected the distance between the knees and sense of balance.

There was a significant difference in the change in the knee distance between the groups. These results were similar to the results of previous studies that showed significant differences in the experimental group as a result of corrective exercise. Stretching, band exercises, and sling exercises strengthened the tissue around the knee joint and improved physical disabilities.[21] Previous studies that used a corrective exercise program with elastic band exercises and stretching demonstrated significant improvement in the experimental group compared to the control group. This finding was because the corrective exercise program provided correct lower limb alignment through muscle strength and relaxation.

The distance between the knees significantly decreased in both the complex exercise group and the taping group. A significant difference in the interval between the knees before and after the exercises was reported as a result of stretching the hip joint synovial muscle and the femoral fascia tension muscle to correct the internal rotation of the femur due to genu varum. Similar to this study, this finding was attributed to the effects of stretching the connective tissue around the knee joint in the adductor muscle and the tensor fascia latae tension muscle.[22] A previous study revealed that there was a significant difference in the distance between the knees before and after exercise. The application of elastic band exercises suggested that strengthening the lateral rotator muscle group improves the muscle strength of the knee joint and reduces the distance between the knees.

Resistive exercises performed in repetition and resistance band exercises, which improve the strength in the hip external rotators, are effective for patients with genu varum. It has also been reported that squats improve the structures surrounding the knee joint. In this study, the complex exercise group experienced a decrease in the distance between the knees. These exercises included narrow squats that aided in stretching the hip adductors and the tenor fasciae latae.

We determined that the range of motion increased. The taping group experienced a decrease in the distance of the knees, and we determined that alignment and stability in the lower extremities were induced by taping. There was a significant difference in the change in dynamic balance ability between the groups. A previous study that used musical jump rope exercises in 40 people without a medical history of abnormalities in their lower extremities demonstrated that there were no significant differences in the dynamic balance ability between the groups before and after exercise.[23] In a prior study conducted on 14 patients with knee arthritis, there was no significant difference in the dynamic balance between the experimental group, which performed lower extremity strength training and dynamic balance training, and the control group, which only performed lower extremity strength training. It was reported that exercise was more effective than balance training.[24]

There was a significant decrease in the change in dynamic balance ability within the groups before and after the intervention. This finding was similar to the results of previous studies that demonstrated a significant decrease in dynamic balance between groups when exercise with the PNF (Proprioceptive neuromuscular facilitation) lower extremity pattern was used, and excessive exercise caused muscle fatigue and affected balance, resulting in a significant decrease in dynamic balance.[25]

There was no significant difference in the change in the static balance ability between the groups. These results of a previous study showed that there was no significant difference between the groups when comparing the static balance ability in women in their twenties by applying core muscle strengthening exercises for nine weeks. In accordance with the reported results of the previous study, there were no significant results, since the participants were only young women in their 20s.[26] In addition, similar results were shown in a previous study in which the static balance was measured in female participants aged 65 years or older who participated in elastic band exercises.[27]

For the change in static balance ability, when the right foot was supported and both eyes were open, the trace length and std. velocity significantly increased within the groups, and when the left foot was supported and both eyes were closed, the trace length in both the complex exercise group and the taping group significantly decreased.

In the complex exercise group, the C90 area significantly increased and the std. velocity significantly increased. The trace length and std. velocity significantly decreased. These results were similar to the results of previous studies that analyzed static balance

with exercise and taping in the elderly. In this study, when participants' eyes were open with the right foot supported, there was a significant difference in the taping group, and when participants' eyes were closed, a significant difference was present in both the left and right foot groups. The right foot showed a significant difference only in the exercise group. After implementing balance training in the elderly, there was a significant decrease in the participants' velocity and force.[28] In addition, the results of applying the PNF integrated pattern training in 28 hockey players were similar to the results of previous studies that showed significant differences in the distance variable moved in both an experimental group and a control group.[29] When healthy adults participated in aquatic exercises, trunk stabilization exercises, and balance exercises, the static balance before and after exercises was compared, and the results were similar to the results of previous studies that showed a significant decrease in the moving area in all groups.[30]

Based on these previous studies, the complex exercise program conducted in this study was effective for static and dynamic balance. This finding is because stretching, elastic band exercises, and squat exercises are dynamic movements that improve mobility, balance control, and weight movement in the lower limbs. It is believed that these exercises improved the balance ability through these movements. In addition, kinesiology taping also improved dynamic and static balance, and it is believed that taping promotes muscle function and improves balance ability by controlling muscle activity. In this study, there were 20 adults in their twenties. Therefore, the age and number of participants were limited. The exercise period was 6 weeks, which was a short period, and the variables measured the interval between the knees and balance. Therefore, the application of mid- to long-term rather than short-term exercise programs with various age groups is necessary in future studies. It is thought that research including kinematic analysis of other joints as well as the distance between knees and balance is necessary.

## CONCLUSION

This study used a complex exercise program, which included elastic band exercises and narrow squat exercises for 6 weeks in young adults with varus knees. The effects of these interventions on distance between knees and balance were analyzed. Both the complex exercise group and the taping group showed positive results in the reduction of the distance between knees and improvement in balance.

## REFERENCES


1. Park GD. The effect of Pelvic Manipulation to primary school Students Balance, Flexibility, and LLI. *The Korean Journal of Growth and Development.* 2005;13(2):13-22.
2. Kang SH, Lee WJ, Kim TY. Possible Effects of Applying Rehabilitation Program upon Bowlegged Undergraduates` COG(Center of Gravity) Oscillation and its Correction. *Journal of Sport and Leisure Studies.* 2009;35:1061-1072.
3. Greenberg LA, Swartz AA. Genu varum and genu valgum. Another look. *Am J Dis Child.* 1971;121(3):219-221.
4. Kim KS, Lee JS. The Effect of Chuna Manual and Taping Treatment on Genu Varum. *Journal of oriental rehabilitation medicine.* 2010;20(3):93-107.
5. Samaei A, Bakhtiary AH, Elham F, et al. Effects of genu varum deformity on postural stability. Int *J Sports Med.* 2012;33(6):469-473.
6. Sahrmann S. *Movement System Impairment Syndromes of the Extremities, Cervical and Thoracic Spines.* St Louis: Mosby; 2010.
7. Han SM, Lee KK, Ha S, et al. The Effects of Correction Exercise on Hip joint angle, Q angle, and the Distance between Knees of Genu Varum Patients. *J Korean Acad Kinesiol.* 2010;13(1):83-90.
8. Park SR, Ro HR, Namkoong S. The Effect of Stretching and Elastic Band Exercises Knee Space Distance and Plantar Pressure Distribution during Walking in Young Individuals with Genu Varum. *J Korean Soc Phys Med.* 2017;12(1):83-91.
9. Alsancak S, Guner S. Orthosis Effects on the Gait of a Child with Infantile Tibia Vara. *Case Rep Pediatr.* 2015:1-6.
10. Suh JT, Kim SH, Yoo CI. Ilizarov External Fixation in High Tibial Osteotomy. *Journal of The Korean Orthopaedic Association.* 1995;30(4):989-996.
11. Ham YW. Effects of thera-band exercise on Isotonic strength of flexor muscles in upper extremities. *Journal of Health Science and Medical Technology.* 2000;26(1):49-56
12. Park HS, Lee SN, Lee TH, et al. Comparative Analysis on Muscle Activities of Lower LimbDepending on the Types and Load of Squat

Exercise. *The Korean Journal of Growth and Development.* 2016;24(1):45–51.
13. Lee JD. *The Biomechanical Changes of the Foot and Lower Extremity depending on Dynamic Squat Types in Flatfoot.* [Doctoral thesis]. Gyeongsan: Daegu University; 2012.
14. Han SK. *The Immediately Effect of Narrow Squats on the Knee Joint Biomechanics During a Gait and Distance Between the Knees of Person With Genu–varum.* [Master's thesis]. Seosan: Hanseo University; 2017.
15. AmirAli J, Morteza M, Mahdi M, et al. Effect of kinesio taping on lower limb joint powers in individuals with genu varum. *J Bodyw Mov Ther.* 2018;22(2):511–518.
16. Castrogiovanni P, Di Giunta A, Guglielmino C, et al. The Effects of Exercise and Kinesio Tape on Physical Limitations in Patients with Knee Osteoarthritis. *J Funct Morphol Kinesiol.* 2016;1(4):355–368.
17. Cho SH, Moon HJ. Effects of Kinesio–taping on Balance Abilities and Proprioception Sense. *J Int Acad Phys Ther Res.* 2017;8(2):1163–1167.
18. John L, Karin S. Kinesiology Taping: *The Essential Step–by–step Guide: Taping for Sports, Fitness & Daily Life: 160 Conditions & Ailments.* Canada: Robert Rose incorporated; 2014
19. David J. M. *Orthopedic Physical Assessment.* Canada: Elsevier Health Science; 2013
20. Kim CY, Lim SK. Range of Motion and Isokinetic Strength of Hip Joint in the College Women with Idiopathic Genu Vara. *The Journal of the Korea Contents Association.* 2014;14(10):210–217.
21. Han SM. *A Study on the Effect of Correction Exercise on the Space between Knees of Genu Varum Lower Limbs Deformation.* [Master's thesis]. Seoul: Kookmin University; 2009.
22. Choi KY, Kim JG, Choi MY, et al. The Effects of Exercise Programs on Genu Varum Persons. *Journal of The Korean Society of Integrative Medicine.* 2013;1(1):87–96.
23. Kim YN. *The Immediate Effects of Jumping Rope on the Posture and Dynamic Balance According to Visual Information.* [Master's thesis]. Seoul: Ewha Womans University; 2015.
24. Bang DH, Bong SY. Effects of Dynamic Balance Training on Pain, Physical Function, and Balance Ability in Patients with Chronic Knee Osteoarthritis. *PNF and movement.* 2018; 16(1):105–113.
25. Cho NJ, Kim KH, Choi MS, et al. The effects of the stepper exercise using lower extremity patterns of PNF on ankle muscle strength and balance ability of females in their twenties. *Journal of the Korean Proprioceptive Neuromuscular Facilitation Association.* 2010;8(3):27–38.
26. Park YJ, Lee JS, Seok MG, et al. Effects of 9 weeks core muscle strengthening exercise on static balance, gait balance and maximum gait speed for women in twenties. *Korean Journal of Sports Science.* 2016;25(5):1227–1239.
27. Lee HJ, Han SW. Effects of Lower Extremity Muscle Strengthening Exercise Using Elastic Resistance on Balance on Elderly Women. *J Korean Acad Community Health Nurs.* 2009; 20(1):59–66.
28. Lee KJ, Kim SJ, Song CH. Effects of Cognitive Task Balance Training using BIORescue Program on Static Balance, Dynamic Balance and Visual Perception in Elderly. *Journal of Special Education & Rehabilitation Science.* 2012;51(1): 211–229.
29. Ann YD, Park JH. The effects of PNF combined patterns training on balance ability and functional ability of hockey players. *The Journal of digital policy & management.* 2013;11(11):521–528.
30. Kang JI, Park JS, Park SK, et al. Effects of Exercise Program by Type on Balance Ability and Muscle Activity In A Standing Posture. *Journal of Digital Convergence.* 2014;12(7):411–418.