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Effects of Heel Raising Exercise whith Kinesio Taping on Triceps Surae Muscle Activity and Balance in 20s Adults

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키네시오 테이핑을 결합한 발 뒤꿈치 들기 운동이 건강한 성인의 하지 근활성도 및 균형에 미치는 영향

장근환 · 인태성 · 김경훈

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Abstract

Background: The aim of this study was to investigate the effects of heel raising with kinesio taping (HRKT) on triceps surae muscle activity and balance in 20s adults.

Design: Two groups pre-post randomized controlled design.

Methods: The total of 40 subjects were randomly divided in the HRKT group (experimental group, *n*=21) and heel raising with sham kinesio taping (control group, n=19). Both groups receive heel raising with kinesio taping and sham kinesio taping for 20 minutes a day, five day per week, for four weeks. Measurement were performed before training and 4 weeks after training. The triceps surae muscle activity was measured using the EMG. A functional reach test (FRT) was used to evaluate balance ability. The independent t-test was conducted to compare exercise methods depending on the taping effect on each group.

Results: The both group showed significant differences in muscle activity of lower extremity and functional reach test in the pre-post intervention comparison (p<0.05). The experimental group showed significantly more improvement in triceps surae muscle activity and functional reach test compared to the control group(p<0.05).

Conclusion: We confirmed that the effects of heel-raising with kinesio taping group on triceps surae muscle activity and balance ability in 20s adults. The result suggest that heel raising with kinesio taping for 20s adults should be further studied and considered.

Key words: heel raising, gastrocnemius muscle, kinesio taping, soleus muscle.

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Ⅰ. Introduction

Obesity leads to a burden on the joints as a result of BMI and being overweight. In particular, increased pressure on the ankles increases the probability of injury (Kim and Oh, 2007). A comparative analysis of leg strength depending on the gait velocity between people with normal weight and people with obesity found that pressure on the ankles increased for people with obesity, and the consequent weakening of strength increased the amount of damage (Kim, 2006). Preceding studies related to this topic reported instability in the hip joints, knee joints, and the ankles due to an increase in BMI and weight (Andersen et al., 2003). Furthermore, ankle instability can damage the surrounding area of the ankles due to the impact of decreased motor skills, strength, and postural stability and the delay in muscle reflexes (Korandsen, 2002; Riemann et al., 2002; Vaes et al., 2002).

Methods for increasing ankle stability include trampoline and balance pad exercises (Im et al., 2010), whole-body vibration training(Jin et al., 2018), heel raising exercises (Ema et al., 2017), and Kinesio taping (Nunes et al., 2021; Lee et al., 2022; Eom et al., 2018). A look into the effects of heel raising exercises (HRS) shows that, as a relatively easy and simple exercise method, it can strengthen the plantar flexor muscles of the ankle joints (Flanagan et al., 2005). It also leads to a rise in blood flow volume in the arteries, ultimately decreasing cardiovascular risk factors, and regular HRS is reported to generate enough strength to maintain stability during lower-body exercises, improving balance and strength (Richardson et al., 2001; Youm and Kim, 2012). Adults with achilles tendinitis, who did HRS for 12 weeks, reported a decrease in pain and an increase in function over the group that did eccentric calf muscle exercises (Rabusin et al., 2021). Furthermore, calf muscles provide ankle stability by moving when standing or adjusting one’s posture and serve as important muscles for raising the heels off the surface by contracting (Winter, 1991).

Kinesio taping is a therapy that accelerates blood circulation and assists the muscles by applying special tape to particular areas of the muscles (Go, 2002), and elastic Kinesio taping balances the muscles and the joints, alleviates pain, and increases flexibility (Lee et al., 2005). Applying taping therapy to the group of muscles around the ankles has been proven to be effective for ankle joint stability, and thus it is variously used in clinical settings (Gilleard et al., 1998).

As demonstrated, a variety of studies have aimed at increasing ankle stability, but there is a lack of studies that combine HRS and Kinesio taping. Kinesio taping and HRS are important elements for improving ankle stability. Therefore, this study was attempted to examine the effects of the Kinesio taping combined with HRS on muscle activity of the triceps and balance in 20s adults.

Ⅱ. Methods

1. Study Design

This study applied a single-blind test and consisted of a two-group randomized pre-post design.

2. Subjects

This study conducted experiments using 42 adult subjects in their 20s, who were attending G university in Gimcheon, Gyeongbuk. The inclusion criteria were as follows: adult men and women in their 20s, neurological damage to the ankles in the past six months, voluntarily took part in the study and signed a consent form after listening to an explanation on the entire procedure of the experiment and its methods. The exclusion criteria were as follows: musculoskeletal disorders in their lower limbs, skin diseases, ankle sprains, contusions, or fractures.

3. Procedure

The Randomizer (https://www.randomizer.org) was used to minimize subject bias, and thus subjects were randomly assigned to the experiment group (*n*=21) and the control group (*n*=19). Muscle activity tests and functional reaching tests were conducted before the experiment and four weeks after the experiment. All subjects underwent a total of 20 exercise sessions five times per week for 4 weeks, and 20 min a day.

4. Experiment Method

1) Experiment Group

The experiment group performed ankle raising exercises with Kinesio taping applied to their calf muscles. Kinesio tape (SIGMAX, 2012, Japan, 5cm width) was used, and the method of applying the tape was revised and supplemented to apply a Y-shape strip to the medial/lateral side of the gastrocnemius muscles, specifically, 2cm below the end of the heels with the subjects knees bent, and the split portions of the tape following along the inner and outer sides of the calves while passing the top of the achilles tendon with the subjects maintaining maximum dorsiflexion (Stedge at al, 2012). The soleus was split in a straight line, and an I-shape strip was applied from below the knees to 2cm below the end of the heels (Kase, 1998; Kase, 2003; Kim, 2020) <Fig 1>. The elasticity of the tape was attached using a tension of 10-15%.. HRS was conducted after supplementing and revising the method suggested by Ema et al. (2017) HRS was repeated for 20 minutes, with the subject standing barefoot in a designated place and then raising their heels as much as possible before slowly lowering their heels <Fig 2>. In order to prevent falls during exercises, a therapist was positioned beside the participant.

Fig 1. Kinesio taping and sham Kinesio taping

Fig 2. Heel raising with kinesio taping exercise

2) Control Group

The control group undertook HRS with placebo Kinesio taping applied. Using placebo Kinesio taping (SIGMAX, 2012, Japan, 5cm width), the study applied three short strips using the same material to the end of the heels and the head of the medial/lateral gastrocnemius muscle (Han, 2020).

5. Outcome Measurements

1) Muscle Activity of the Lower Limbs

The Noraxon TeleMyo Mini DTS System was the surface EMG system used to measure the muscle activity of the gastrocnemius and soleus muscles. The digitally processed EMG signals on the surface EMG system were processed using the MyoResearch 3.14.38 program from Noraxon on a personal computer. The skin and electrode locations were prepared following the methods of Hermens et al.(1999) and Merletti and Tonio (1999). The area where the electrodes were to be attached was cleaned using alcohol cotton balls in order to minimize impedance against the EMG signals generated on the skin before attaching the electrodes. The EMG signals of the medial soleus and the lateral gastrocnemius were recorded with surface electrodes, and skin and electrode locations were prepared. In order to measure the medial gastrocnemius, the bipolar surface electrodes were attached where the medial circumference was the greatest at a spot 1/3 to the calves from the knees. For the lateral gastrocnemius, the electrodes were again attached to where the lateral circumference was the greatest at a spot 1/3 to the calves from the knees. For the soleus, the electrodes were attached at a 2/3 point between the medial protuberance of the thigh and the medial malleolus of the ankle. A 3-channel surface EMG device was used to measure the EMG signals. In order to collect EMG signals, the sampling rate was set at 1,500Hz and the notch filter at 60Hz, with the signals processed using root mean square(RMS) for the analysis. MVIC was applied to each lower limb muscle, and the study used data from three-seconds in the middle of the test excluding one-second from before and after the test. The subjects underwent HRM testing while standing on one leg in order to investigate the lower limb muscle activity of the triceps surae. The subjects looked straight ahead and placed two fingers from their dominant hand on the examination table in order to maintain balance while standing upright. They then adjusted their knee flexion angle to 0 degrees while standing on one leg using their dominant leg. Three sets of HRS were then conducted with a measurement duration of 5 seconds followed by a 5-second break (Kwon and Song, 2013).

2) Functional Reaching Test

The functional reaching test (FRT) was developed by Duncan et al.(1990) in order to quickly ascertain balance issues. During testing, limitations in terms of stability regarding the movement of the upper body and the postural reflexes were tested. The testers were made to familiarize themselves with the measurement methods of FRT. The research subjects wore simple clothing that didn’t interfere with the measurements. During FRT measurements, subjects straightened their elbows while standing and then reached forward while one arm remained horizontal and the shoulders were bent by about 90 degrees Then, the maximum distance (3cm) reached forward from the end of the middle finger with the subjects standing was measured three times. Precautions were also taken to avoid knee flexion and the retrodisplacement of the pelivs and buttocks. The measurements were made by using a yard stick marked in cm, which was attached at shoulder height to the subjects (Choi and No, 2019).

6. Statistical Analysis

Statistical analyses this study was analyzed using the Windows SPSS (Version 20.0, Chicago, Illinois). Normality tests was analyzed using the Shapori-Wilk test. The independent t-test was conducted to compare exercise methods depending on the taping effect on each group. The paired t-test was conducted to identify differences before and after the experiment in regard to dependent variables within each group. All levels of statistical significance were set at α= 0.05.

Ⅲ. Results

1. General Characteristics of the Participants

The height of the experiment group was 168.71±8.94 cm, and for the control group, it was 168.05±12.14 cm. The weight of the experiment group was 69.67±12.23 kg and for the control group, it was 67.16±16.77 kg. The age of the experiment group was 21.95±1.43 years old, and for the control group, it was 22.29±1.42. In terms of gender, 14 were male and 7 were female in the experiment group, while 11 were male and 8 were female in the control group. In terms of dominant leg, 16 were right-legged and 5 were left-legged in the experiment group, while 14 were right-legged and 5 were left-legged in the control group. Two males in the control group quit during the study, and thus a total of 40 subjects participated in the study. The general characteristics of the subjects in both groups appeared to be homogeneous as indicated in <Table 1>.

Table 1. General Characteristics of Participants (*N*=40)

	Experimental group (*n*=21)	Control group (*n*=19)	*p*
Height (cm)	168.71±8.94	168.05±12.14	0.844[a]
Weight (kg)	69.67±12.23	67.16±16.77	0.589[a]
Age (year)	21.95±1.43	22.29±1.42	0.363[a]
Gender (male/female)	14/7	11/8	0.567[b]
Dominant leg (Right/Left)	16/5	14/5	0.855[b]

The values are presented mean (SD), [a]Independentt-test, [b]Chi-squaretest, Experimental group=heel raising with kinesio taping of calf muscle; Control group=heel raising with sham kinesio taping of calf muscle.

2. Changes in Muscle Activity

For the experiment group, the medial gastrocnemius improved from 81.01±9.14 %MVIC before the experiment to 86.49±7.94 %MVIC after the experiment, demonstrating a statistically significant difference (p<0.05). For the control group, the medial gastrocnemius increased from a mean EMG value of 79.03±7.47 %MVIC before the experiment to 80.56±7.26 %MVIC after the experiment, demonstrating a statistically significant difference (p<0.05). Medial gastrocnemius significantly increased in the experiment group (5.49±3.84 %MVIC) compared ti the control (1.53±0.98 %MVIC) after intervention (p<0.05)<Table 2>.

For the experiment group, the lateral gastrocnemius improved from 58.26±6.95 %MVIC before the experiment to 60.91±7.21 %MVIC after the experiment, demonstrating a statistically significant difference ($p<0.05$). For the control group, the lateral gastrocnemius increased from a mean EMG value of 57.04±5.98 %MVIC before the experiment to 58.45±5.93 %MVIC after the experiment, demonstrating a statistically significant difference ($p<0.05$). Lateral gastrocnemius significantly increased in the experiment group (2.65±1.80 %MVIC) compared ti the control (1.41±1.10 %MVIC) after intervention ($p<0.05$)<Table 2>.

For the experiment group, the soleus improved from 55.80±7.00 %MVIC before the experiment to 58.74±6.87 %MVIC after the experiment, demonstrating a statistically significant difference ($p<0.05$). For the control group, the soleus increased from a mean EMG value of 54.77±8.82 %MVIC before the experiment to 55.96±7.70 %MVIC after the experiment, demonstrating a statistically significant difference ($p<0.05$). Soleus significantly increased in the experiment group (2.94±1.65 %MVIC) compared ti the control (1.19±1.83 %MVIC) after intervention ($p<0.05$)<Table 2>.

Table 2. Comparison of muscle activity of lower extremity (N=40)

Variable		Experimental group (n=21)	Control group (n=19)	t (p)	Effects d
MED (Hz)	pre	81.01±9.14	79.03±7.47	0.421 (0.462)	0.2372146
	post	86.49±7.94	80.56±7.26		0.7875517
	change	5.49±3.84	1.53±0.98	4.362 (0.000)*	1.413115
	t (p)	-6.546 (0.000)*	-6.788 (0.000)*		
LA (Hz)	pre	58.26±6.95	57.04±5.98	0.591 (0.558)	0.1881796
	post	60.91±7.21	58.45±5.93		0.3726653
	change	2.65±1.80	1.41±1.10	2.592 (0.013)*	0.8312979
	t (p)	-6.751 (0.000)*	-5.619 (0.000)*		
SO (Hz)	pre	55.80±7.00	54.77±8.82	0.410 (0.684)	0.1293617
	post	58.74±6.87	55.96±7.70		0.3809884
	change	2.94±1.65	1.19±1.83	3.178 (0.003)*	1.004404
	t (p)	-8.184 (0.000)*	-2.835 (0.011)*		

M±SD, *$p<0.05$, Experimental group=heel raising with kinesio taping of calf muscle; Control group=heel raising with sham kinesio taping of calf muscle; MED=medial gastrocnemius; LA=lateral gastrocnemius; SO=soleus.

3. Changes in FRT

For the experiment group, the FRT improved from 33.19±4.40 ㎝ before the experiment to 37.24±4.60 ㎝ after the experiment, demonstrating a statistically significant difference ($p<0.05$). For the control group, the FRT increased from a mean EMG value of 32.11±4.36 ㎝ before the experiment to 34.00±3.40 ㎝ after the experiment, demonstrating a statistically significant difference ($p<0.05$). FRT significantly increased in the experiment group (4.05±3.51 ㎝) compared ti the control (1.89±1.24 ㎝) after intervention ($p<0.05$)<Table 3>.

Table 3. Comparison functional Reaching Test (*N*=40)

Variable		Experimental group (*n*=21)	Control group (*n*=19)	t (*p*)	Effects d
FRT (cm)	pre	33.19±4.40	32.11±4.36	0.783 (0.439)	0.2465728
	post	37.24±4.60	34.00±3.40		0.8010384
	change	4.05±3.51	1.89±1.24	2.529 (0.014)*	0.8205842
	t (*p*)	-5.279 (0.000)*	-6.647 (0.000)*		

M±SD, *$p<0.05$, Experimental group=heel raising with kinesio taping of calf muscle; Control group=heel raising with sham kinesio taping of calf muscle.

Ⅳ. Discussion

This study was conducted to investigate whether Kinesio taping exercises combined with HRS impact the muscle activity of the triceps surae and balance of adult college students. Data before conducting the experiment and four weeks after the experiment were compared and analyzed. The results show that the experiment group exhibited a statistically significant difference over the control group in terms of muscle activity in the triceps surae and balance.

The triceps surae, which serves an important role during plantar flexion (i.e. HRS involving the raising of the torso while supporting one's body weight), consists of the medial and lateral gastrocnemius and soleus, and because it has a different proportion of muscle fiber, it is a muscle adequate for comparing EMG (Shin, 1998). Important for maintaining center of mass over the base of support (BOS) by continuing to contract while walking (Jo et al., 2017), the calf muscles generate the strength to maintain stability during exercise and thus they greatly impact balance (Rabusin et al., 2021).

The results of the study found a greater level of statistically significant differences in the experiment group than in the control group in terms of value changes in the muscle activity of the lower limbs. The results of the experiment agree with the research results of Yang et al (2011) that claim an improvement in muscle activity after Kinesio taping experiments, as well as with the study by Ema at al (2017) which examined how HRS changes muscle activity in the lower limbs and balance and found that HRS improves muscle activity. Based on these results, researchers believe that increased metabolism in the muscles of the subjects removes metabolites, thereby increasing blood circulation, which leads to increased muscle activity in the lower limbs. Furthermore, HRS and Kinesio taping raise the motor educability of the subjects, increasing balance and the muscle activity of the lower limbs. In addition, HRS and Kinesio taping increase the afferent feedback of the calf muscle group, thereby providing more information to the central nervous system. They also increase efferent feedback, and thus muscle spindles activate exercise posture and muscle conditions so that these two types of information correspond to each other, creating a huge synergy effect for balance and the muscle activity of the lower limbs.

Balance is the ability to maintain one's center of gravity within one's base of support, as well as equilibrium even amidst the movement of the body (Nashner, 1989). In terms of biomechanics, various areas have an impact on postural stability. In particular, ankle strategy mainly centralizes body movement around the ankle joints and serves the important function of returning the center of the body to a stable position (Seo et al., 2017). The FRT suggested by Duncan et al.(1992) is suggested as a balance measurement method because it is easy to apply and simple, with a high degree of reliability and validity.

The results of this study show a greater level of statistically significant differences in the experiment group than in the control group in terms of value changes in the FRT. The results agree with the study by Ema et al (2017) which claims that HRS improves the balance of the lower limbs. Furthermore, the results also correspond to the study by Hinman et al (2003) which argues that Kinesio taping increases the postural balance index, reduces muscle mobilization time, and improves the proprioceptive feedback mechanism, thereby increasing proprioception. This implies that HRS and Kinesio taping increase the afferent feedback of the calf muscle group, thereby providing more information to the central nervous system. It also implies that they increase efferent feedback, and, as a result, muscle spindles activate exercise posture and muscle conditions so that these two types of information correspond to each other, creating a huge synergy effect for balance and the muscle activity of the lower limbs. Moreover, ankle strategy achieves anticipatory postural adjustment (APA), minimizing the postural sway area appearing in the feed forward method and thus increasing balance (Song et al., 2011; Massion, 1994; Shumway-Cook and Horak, 1986; Wolfson et al., 1986).

This study has several limitations. First, the study failed to confirm long-term effects via a follow-up survey. Second, it wasn’t able to completely control the daily lives of the subjects.

Ⅴ. Conclusion

This study attempted to examine how HRS combined with Kinesio taping, performed by adult men and women in their 20s, impacted the muscle activity of the triceps surae and balance. Our results indicate that a greater level of significant differences was observed in the experiment group than in the control group in regard to the muscle activity of the triceps surae and FRT. Based on the results of This study, it will be possible to apply the experiment methods, aimed at resolving body imbalance, to not just ordinary people but also patients who require increased muscle activity as well as increased body balance.

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