

## Original Article

# Immediate effect of patellar kinesiology tape application on quadriceps peak moment following muscle fatigue: A randomized controlled study

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## Abstract

**Objective:** To investigate the immediate effect of horseshoe taping for patellar superior and inferior gliding (HTPSG and HTPIG, respectively) using kinesiology tape on the peak moment of fatigued quadriceps. **Methods:** Twenty-eight adults were divided into the HTPSG (experimental) and HTPIG (control) groups. The peak moment of the dominant quadriceps of the participants was measured using Biodex System 4 prior to the experiment and after inducing quadriceps fatigue. The peak moment of the quadriceps was measured after separate application of HTPSG and HTPIG using kinesiology tape. **Results:** After kinesiology tape application, the peak moment of the quadriceps muscle was significantly increased in both groups ( $p < .05$ ); however, the peak moment of the fatigued quadriceps muscle was significantly higher in the HTPSG group than in the HTPIG group ( $p < .05$ ). **Conclusions:** The application of HTPSG using kinesiology tape would more be helpful for immediate recovery after exercise-induced quadriceps fatigue.

**Keywords:** Kinesiology Taping, Muscle Fatigue, Patella, Quadriceps Muscle

## Introduction

The quadriceps act as the primary dynamic stabilizer of the knee joint<sup>1</sup>, and the patella, which is connected to the distal tendon of the quadriceps, works with the quadriceps during knee extension and flexion for efficient movement<sup>2</sup>. A study showed that repositioning errors increased when muscle fatigue was induced in the quadriceps of healthy young subjects<sup>3</sup>. Muscle fatigue is the phenomenon of reduced ability to contract the muscles after high-intensity training or sustained activity over a long duration<sup>4</sup>. It is

divided into central fatigue, which indicates a decrease in voluntary activation<sup>5</sup>, and peripheral fatigue, which occurs in neuromuscular junctions, includes decreased contractile properties and excitability of the sarcolemma<sup>6</sup>. Fatigue caused by muscle-strengthening exercise impairs postural control<sup>7</sup> as well as joint proprioceptive sense and kinesthesia via its effect on muscle spindle thresholds<sup>8</sup>, and its effects on joint position sense also impact proper motor control ability<sup>9</sup>. Local muscle fatigue is a limiting factor on isokinetic contraction during exercise of muscles attached to the knee and ankle joints<sup>8-15</sup>.

As a component of the knee joint complex, the patella is included in the patellofemoral joint and plays an essential role in the biomechanical mechanisms of knee extension<sup>16,17</sup>. Within the quadriceps, the vastus medialis and vastus lateralis affect the dynamic balance of the patella<sup>18,19</sup>, and the strength of the vastus medialis muscle is especially dependent on the tracking of the patella during the last 30° of knee extension<sup>20,21</sup>. However, physiological weakness of the vastus medialis leads to imbalance within the quadriceps, which increases abnormal movements of the patella<sup>19</sup>. Patellar

The authors have no conflict of interest.

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Edited by: G. Lyritis

Accepted 29 June 2020



malalignment is caused by a reduction in motor unit activity of the vastus medialis and affects several factors including the vastus medialis and vastus lateralis activation ratio and contraction timing<sup>22,23</sup>. When the quadriceps becomes fatigued, it alters the distance of the knee joint lever arm (the distance from the axis of rotation to the line of action of the force), and this is a major cause of changes in the position of the patella<sup>24</sup>. In previous studies, reduced knee joint motion and delayed muscle contraction due to fatigue had negative effects on quadriceps strength and knee stability<sup>25-27</sup>.

As an intervention method for coping with muscle fatigue, kinesiology tape has been shown to be effective at alleviating pain, improving joint range of motion (ROM) and stability<sup>28</sup>, increasing muscle strength<sup>29</sup>, and correcting alignment<sup>30</sup>. Previous studies showed that the skin irritation caused by kinesiology tape application alleviates muscle weakness due to attenuated Ia inhibitory afferent stimulation and affects the gamma motor neuron, thus improving the strength of the quadriceps muscle<sup>29</sup>, and that the elastic materials of the kinesiology tape help alleviate muscle fatigue<sup>31</sup>. Choi and Lee<sup>32,33</sup> reported that muscle strength increased when kinesiology tape was applied to the tired leg muscles of athletes and the occurrence of muscle fatigue was delayed when kinesiology tape was applied to the quadriceps muscles of athletes before inducing quadriceps fatigue.

Previous studies have investigated the effects of kinesiology tape application on quadriceps fatigue by applying kinesiology tape directly to the quadriceps muscle<sup>3,29,32,33</sup>. However, there has been a lack of research on the effects of kinesiology tape application around the patella on fatigued quadriceps strength. Therefore, this study aimed to evaluate the effect of kinesiology tape application around the patella without directly attaching the kinesiology tape to the fatigued quadriceps muscle. We used kinesiology tape to apply horseshoe taping for patellar superior and inferior gliding (HTPSG and HTPIG, respectively)<sup>34</sup> in individuals with quadriceps fatigue and examined the immediate effects on the peak moment of the quadriceps in healthy persons.

## Materials and methods

### Study design

This was a randomized controlled study. HTPSG and HTPIG were performed by a physical therapist with professional experience in horseshoe taping. All measurements of peak moment using isokinetic device were performed at Medwill Hospital Center (Pusan, South Korea) by the same examiners. The examiners had professional experience with the equipment and were blinded to the taping method. All participants gave informed consent before they participated in the study. This study was approved by the institutional review board at Dong Eui University (DIRB-201806-HR-R-25).

### Participants

The number of participants for each group was calculated using G-Power version 3.1 (University of Dusseldorf,



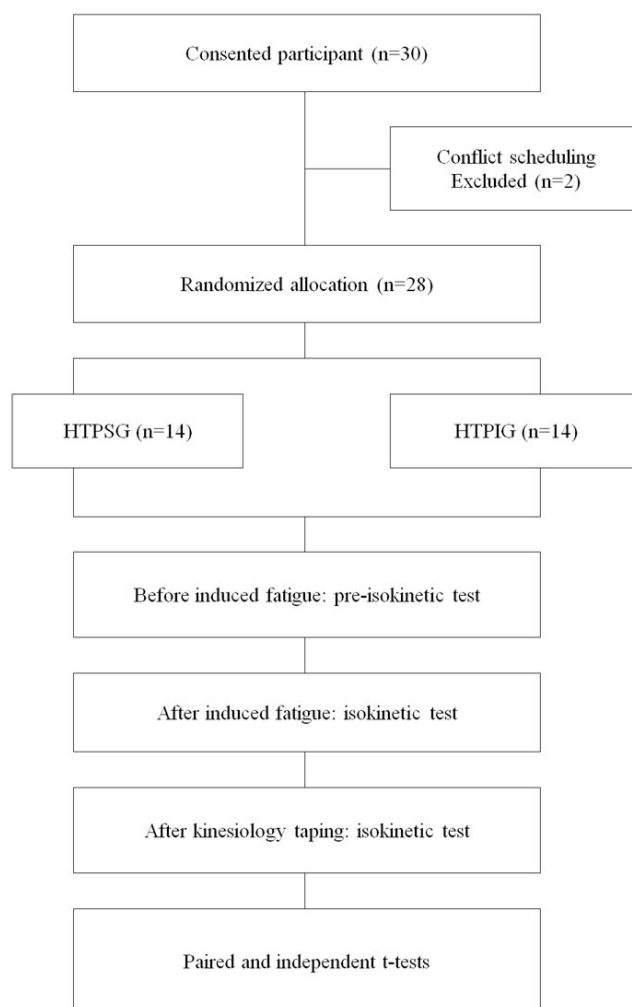
**Figure 1.** Isokinetic Biodex System 4 muscle peak moment measurement.

Dusseldorf, Germany), and assuming a significance level of 0.05, a power of 80%, and an effect size of 0.95, the sample size was 15 for each group. A total of 30 participants were recruited without considering dropouts. However, two participants dropped out because of conflict in scheduling. Thus, a total of 28 participants (13 men and 15 women; age range, 20–29 years) were included in the study. Individuals who had not taken any medication in the last 3 months and had no musculoskeletal or neurological injury, history of surgery on their lower extremities, pain in their lower extremities, restriction of joint ROM in their lower extremities, or history of dermatological adverse reactions to kinesiology tape were eligible.

### Procedures

The participants were randomized to either the HTPSG or HTPIG group using sequentially numbered, opaque, sealed envelopes, as previously described<sup>35</sup>. Briefly, aluminum foil and paper were cut into 28 sheets with uniform size, and the sheets were divided into 2 sets of 14 sheets. The letters A and B were written on each set, and the aluminum foil sheets were folded so that they were not visible on the paper. The sheets were mixed and placed in an envelope. The participants selected paper from the sealed envelope in a separate place.

The peak moment of the quadriceps on the dominant leg was measured in both groups using a Biodex System 4 isokinetic device (Biodex Medical System, Inc., Shirley, NY, USA) (Figure



**Figure 2.** Flow diagram for the study. HTPSG, horseshoe taping for patellar superior gliding; HTPIG, horseshoe taping for patellar inferior gliding.

1). The dominant leg was selected by determining the leg used by the participant when kicking a ball<sup>36</sup>. Biodex System 4 can perform muscle strength measurement and muscle training using concentric and eccentric modes and has demonstrated high test-retest reliability in previous studies (intraclass correlation coefficient, 0.82–0.95)<sup>37,38</sup>. The participant was seated in a Biodex chair, and the trunk, thighs, and ankle were fixed using a belt and the knee was fixed to the dynamometer shaft. The examiner encouraged the participant to exert maximum force. When knee moves at a 60°/s angular velocity, a constant resistance occurs, and when a force greater than the resistance is generated, a curve appears on the monitor. In previous studies, the occurrence of muscle fatigue was based on point when the peak torque at 60°/s angular velocity fell below 50% of the first measured peak torque value at 60°/s angular velocity<sup>12,32,33</sup>. Therefore, in this study, exercise was performed up to 50% of the initial peak torque at 60°/s angular velocity to induce muscle fatigue.

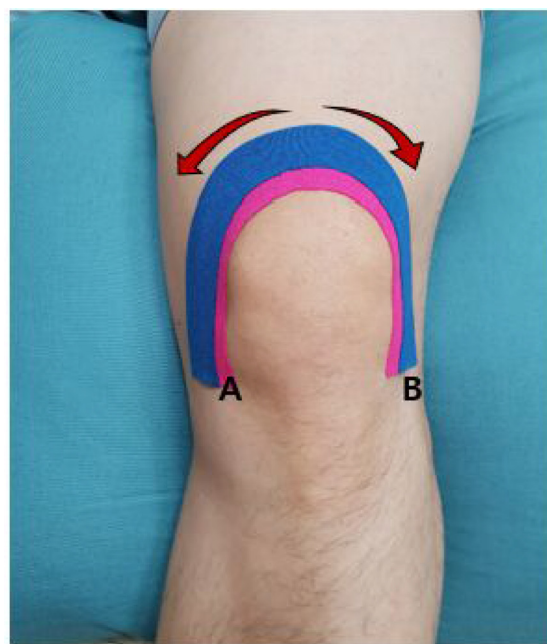
Immediately after fatigue was induced in the dominant quadriceps, either HTPSG or HTPIG was applied on the patella using kinesiology tape, and the peak moment was measured immediately again, without rest, to prevent muscle fatigue recovery. A flowchart of the experimental procedure is provided in Figure 2.

#### *Kinesiology taping technique*

HTPSG and HTPIG were based on balance taping method<sup>34</sup>, using kinesiology tape, applied to the patella of the dominant leg. In HTPSG, the participant's knee was placed in 20°–30° flexion, and a 2.5-cm-wide kinesiology tape (BB Tape; WETAPE, Pyeongtaek, Korea) was stretched by approximately 30–40% and taped from the inferior patellar pole to the superior patella pole on both sides of the patella (Figure 3A). To strengthen patellar superior gliding, another 2.5-cm-wide strip of kinesiology tape was placed to



**Figure 3.** Horseshoe taping for patellar superior gliding.



**Figure 4.** Horseshoe taping for patellar inferior gliding.

**Table 1.** General characteristics of the subjects (n=28).

	HTPSG (n=14)	HTPIG (n=14)	<i>p</i>
<b>Gender (Male/Female)</b>	7/7	6/8	.710
Age (years)	28.57±4.25 <sup>†</sup>	28.64±6.14	.745
Height (cm)	166.07±7.21	164.71±5.52	.519
Weight (kg)	69.86±17.84	62.71±12.87	.232
<b>Dominant leg (Right/Left)</b>	14/0	14/0	

<sup>†</sup>Mean±standard deviation. HTPSG: horseshoe taping for patellar superior gliding; HTPIG: horseshoe taping for patellar inferior gliding.

overlap with the first strip by approximately 50%<sup>34</sup> (Figure 3B). In HTPIG, the participant's knee was placed in 20°–30° flexion, and a 2.5-cm-wide kinesiology tape was stretched by approximately 30–40% and taped from the superior patellar pole to the inferior patella pole on both sides of the patella (Figure 4A). To strengthen patellar inferior gliding, another 2.5-cm-wide strip of kinesiology tape was placed to overlap with the first strip by approximately 50%<sup>34,39</sup> (Figure 4B).

#### Muscle fatigue protocol

To induce quadriceps fatigue, we used the method described by Gribble and Hertel<sup>12</sup>. With the participant sitting on the isokinetic device and the trunk fixed, the peak moment was determined as the highest value during five repetitions of knee exercise at an angular velocity of 60°/sec. Fatigue was considered to be induced when the peak moment fell

below 50% of the peak moment value, for three consecutive repetitions<sup>12</sup>. Participants were verbally encouraged to move the knee as fast as possible.

#### Statistical analysis

Descriptive statistics were used to compare the means and standard deviations of participants' age, height, and body weight between the two groups. Paired-samples t-tests were performed to ascertain the effects of HTPSG and HTPIG kinesiology tape application on the peak moment of the quadriceps after induced fatigue. An independent samples t-test was performed to compare the effects of HTPSG and HTPIG kinesiology tape application between the groups.

SPSS version 18.0 Windows (IBM Corp., Armonk, NY, USA) was used for statistical processing. A *p* value of .05 was used to indicate statistical significance.



**Table 2.** Changes in the peak moment of the fatigued quadriceps before and after kinesiology tape application.

Variables		Peak torque		<i>p</i>
		Pre-taping	Post-taping	
HTPSG (n=14)	60°/sec	93.69±27.46 <sup>†</sup>	114.41±37.73	.000*
HTPIG (n=14)	60°/sec	87.29±27.16	94.42±26.37	.069

<sup>†</sup>Mean±standard deviation. \**p*<.05. HTPSG: horseshoe taping for patellar superior gliding; HTPIG: horseshoe taping for patellar inferior gliding.

**Table 3.** Comparison of the magnitude of change in the peak moment of the fatigued quadriceps depending on the direction of kinesiology tape application.

Angular velocity	Peak torque		<i>p</i>
	HTPSG (n=14)	HTPIG (n=14)	
60°/sec	20.72±4.16 <sup>†</sup>	7.14±13.49	.021*

<sup>†</sup>Mean±standard deviation. \**p*<.05. HTPSG: horseshoe taping for patellar superior gliding; HTPIG: horseshoe taping for patellar inferior gliding.

## Results

### 1. General characteristics of the subjects

The participants' general characteristics are shown in Table 1. The general characteristics were not significantly different between the two groups.

### 2. Changes in fatigued quadriceps peak moment before and after kinesiology tape application

The HTPSG group showed significant increases in peak moment compared with pre-kinesiology taping (*p*<.05). However, the HTPIG group did not show significant increases in peak moment compared with pre-kinesiology taping (*p*>.05) (Table 2).

### 3. Comparison of magnitude of change in fatigued quadriceps peak moment depending on the direction of kinesiology tape application

Comparison between the HTPSG and HTPIG groups showed that the HTPSG group had a significantly larger increase in peak moment than the HTPIG group (*p*<.05) (Table 3).

## Discussion

This study aimed to investigate the immediate effect of HTPSG and HTPIG application using kinesiology tape on the peak moment of the quadriceps with exercise-induced fatigue.

Our results showed that HTPSG caused a significant increase in peak moment compared with pre-kinesiology taping. The patella is used as a spacer to increase the distance from the rotational axis to the internal force lifting the leg

between the femur and the quadriceps muscle<sup>17</sup>. The knee joint is a class 3 lever, i.e., the axis of rotation is at one end of the bone, and it provides a mechanical advantage when the force of action is always stronger than the external force<sup>17</sup>. The force exerted by the body creates a rotation of the joints at a distance from the axis of rotation in the joint. The internal moment arm is the shortest perpendicular distance between the rotational axis and the force<sup>17</sup>. When the lower leg is raised during knee extension, it demands more strength from the quadriceps muscle, because when the patella increases the moment arm, the knee can extend efficiently during quadriceps contraction<sup>17</sup>. During knee extension, because of quadriceps contraction, the force on the lever arm is transferred to the tibia, and the tibia is instantaneously rotated around the axis of the tibiofemoral joint<sup>40</sup>. In addition, the patella moves superiorly during knee extension<sup>41</sup>, and when kinesiology tape is applied to the patella in the HTPSG direction, the patella may shift the quadriceps tendon in the superior direction, shortening the lever arm. Therefore, when kinesiology tape is applied to the patella in the HTPSG direction, the patella increases the length of the internal moment arm<sup>42,43</sup>, thus increasing the peak moment of the fatigued quadriceps muscle<sup>44</sup>.

When kinesiology tape was applied to the patella in the HTPIG direction after inducing fatigue in the quadriceps, the peak moment of the quadriceps muscle increased, but the difference was not statistically significant. Fatigue causes increased muscle stiffness, and the length of the muscle shortens<sup>45-47</sup>. When kinesiology tape is applied in the HTPIG direction, to give the mechanical effect of inferior gliding, it temporarily increases the length of the quadriceps muscle<sup>48,49</sup> and is thought to affect the peak moment of the quadriceps muscle by altering the length-tension curve.

However, stretching of fatigued muscles reduces tendon stiffness and affects the muscle's series elastic component, reducing muscle strength<sup>50</sup>. In a previous study, muscle strength decreased when stretching was applied to the fatigued hamstring<sup>50</sup>. Therefore, when HTPIG is applied for a long time, the peak torque may be reduced. Future research on the long-term effects of the application of HTPIG on quadriceps fatigue should be conducted.

This study has several limitations. First, because we only measured the immediate effect after inducing fatigue in quadriceps muscle, we were unable to analyze the sustained effects of HTPSG and HTPIG. Second, we were unable to study the static and dynamic movements at various angular velocities before and after inducing fatigue in the quadriceps muscle. Third, we were unable to compare the effects of kinesiology tape with other interventions targeting the patella after induction of fatigue in the quadriceps muscle. Fourth, we did not have a group without kinesiology taping. Fifth, functional, balance tests, and subjective fatigue tests were not conducted besides the peak moment using Biodex System 4 because muscle fatigue can recover if there too many measurement periods. Sixth, we could not confirm the results for long term effects of HTPSG. Therefore, further research is needed to resolve these limitations. In addition, further studies comparing the effects of kinesiology taping directly to the quadriceps and kinesiology taping around the patella of athletes with exercise-induced quadriceps fatigue are needed.

## Conclusions

In this study, we found that the application of HTPSG using kinesiology tape around the patella increased the peak moment compared with pre-kinesiology taping after exercise-induced quadriceps fatigue. Therefore, we suggest that the application of HTPSG using kinesiology tape would more be helpful for immediate recovery after exercise-induced quadriceps fatigue.

### Acknowledgements

*This manuscript is a condensed form of the first author's master's thesis from Dong-Eui University.*

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