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The Effect of Kinesio Tape Application on Hamstring and Gastrocnemius Muscles in Healthy Young Adults

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There are no conflicts of interest.
SUMMARY

Background: Scarce evidence exists about effectiveness and mechanisms of action of Kinesio tape (KT) application.

Objectives: To evaluate the effect of KT application over the gastrocnemius or hamstring on range of motion and peak force.

Methods: Thirty-six physical therapy students participated (18 per group). KT was applied with 30% tension for 48 hours to: Group 1- the gastrocnemius; Group 2- the hamstrings. The straight leg raise (SLR), knee extension angle (KEA), weight bearing ankle dorsiflexion, gastrocnemius, quadriceps and hamstrings peak forces were evaluated prior to application, 15 minutes and 48 hours after.

Results and conclusions: A significant increase of peak force in the gastrocnemius group appeared immediately and two days later; no immediate change of peak force in the hamstrings group, however, two days later, peak force significantly increased. SLR and ankle dorsiflexion increased immediately in the gastrocnemius group; KEA improved significantly only after two days. It is possible that certain muscles react differently when KT is applied, and the effect may be subsequently detected.

KEYWORDS

Kinesio tape

Physiotherapy techniques

Range of motion

Muscle strength
INTRODUCTION

For the past 30 years, Kinesio tape (KT), an elastic tape, has gained in popularity (Huang et al. 2011). KT is comprised of a polymer elastic strand warped by 100% cotton fibers and designed to allow a longitudinal stretch of 55-60% of its resting length. Its thickness is approximately the same as the epidermis of the skin (Kase et al. 2003). Kinesio taping has been suggested for corrections of soft tissue movement, fascia and muscle relaxation, ligament and tendon support, movement rectification and lymphatic fluid circulation (Huang et al. 2011). It is currently regarded by physiotherapists as a supportive method of rehabilitation that modify certain physiological processes, such as improving muscle elasticity and strength (Slupik et al. 2007).

In recent years the use of KT has been exponentially growing. One of the factors that facilitate the popularity of KT is its wide use by elite athletes during various world championships and Olympic Games. Although KT is widely used, scarce evidence exists as to its effectiveness and mechanisms of action. Numerous studies have evaluated the effect of KT on sports injuries (Akbas et al. 2011; Chang et al. 2010; Williams et al. 2012), pain reduction (Castro-Sanchez et al. 2012; Chang et al. 2012; Chen et al. 2012; Gonzalez-Iglesias et al. 2009; Kalichman et al. 2010; Kaya et al. 2011; Koss and Munz 2010; Krajczy et al. 2012; Lee et al. 2012; Martín-Sánchez and Yuste-Rodríguez 2012; Paoloni et al. 2011; Thelen et al. 2008), range of motion (ROM) change (An et al. 2012), and muscle force (Callegari et al. 2012; Chang et al. 2012; Fratocchi et al. 2012a; Lee et al. 2012; Vercelli et al. 2012). However, the results were contradictory. Additional studies are warranted to corroborate this method.

Hamstring muscles play a crucial role in the performance of many daily activities, such as walking, running, jumping and controlling movement of the trunk. During the gait
cycle, the hamstrings mainly assist in stabilizing and generating movement in the knee. During running, a faster contraction is needed for shock absorption and leg deceleration (Yu et al. 2008). Research has shown that the hamstring muscles elongate by 50%-90% during a gait cycle (Chumanov et al. 2011). The hamstring's lack of flexibility is one of the risk factors of muscle stretch injuries (Cross and Worrell 1999; Hartig and Henderson 1999). Stretching injuries of the hamstrings are the most common injuries among athletes, comprising 11% of all lower limb injuries and often causing significant loss of activity (Orchard and Seward 2002). Moreover, a direct relationship was found between the lack of flexibility in the hamstrings and low back pain (Li et al. 1996; Tafazzoli and Lamontagne 1996).

The triceps surae (gastrocnemius and soleus) accounts for approximately 80-90% of plantar flexion strength, with the gastrocnemius contributing about 40-43% (Chimera et al. 2010). Gastrocnemius contracture limits the ankle ROM and may decrease the strength of the triceps surae, which may affect walking (Chimera et al. 2010). The gastrocnemius is considered at high risk for strains since it crosses two joints (the knee and ankle) and has a high density of type two fast twitch muscle fibers (Bryan Dixon 2009). Injury to the gastrocnemius muscle is among the more common injuries occurring in the lower leg (12%) (Armfield et al. 2006).

According to recent anatomical studies, myofascial continuity exists between the gastrocnemius and the hamstrings (Myers 2008; Tuncay et al. 2007). Strain, increased tension in one of the muscles, trauma, scar or other restrictions to the fascial glide could cause movement restriction or decrease in strength in the structures along the fascial continuity line. We hypothesized that KT, applied over the gastrocnemius muscle,
would increase hamstring muscle strength, as well as ROM of adjacent joints through the fascial connections between these muscles.

Only two studies have specifically evaluated the effect of KT application on hamstrings (Merino-Marban et al. 2011; Merino et al. 2010) and one has evaluated the effect on gastrocnemius (Huang et al. 2011). Considering the importance of these muscles in sport and musculoskeletal medicine, the aim of the present study was to evaluate the effect of the KT application on hamstrings and the gastrocnemius in terms of hip, knee and ankle ROM and quadriceps, hamstrings and gastrocnemius strength.

**METHODS**

**Design**
Quasi-experimental, repeated measures study.

**Setting**
The study was performed at the Department of Physical Therapy, Recanati School for Community Health Professions, Faculty of Health Sciences, Ben Gurion University of the Negev, Beer Sheva, Israel.

**Subjects**
Subjects were recruited through announcements publicizing the aims and inclusion/exclusion criteria of the study. Two groups of 18 apparently healthy students volunteered. The study was approved by the Institutional Review Board of the Recanati School for Community Health Professions.

**Inclusion criteria**
1. Ages 18-35.
2. Healthy.
3. Average or pure score of the Trunk Flexibility Test (unable to touch the floor
with knees fully extended).

**Exclusion criteria**

1. Pregnancy.
2. Pelvis or lower limb surgery during the last 6 months.
3. History of trauma or injury of the hamstrings/triceps surae, knee or ankle.
4. Skin disease or self-reported hypersensitivity to tape (including scar tissue in the acute phase).
5. Any current treatment or physical activity aimed at improving flexibility of the lower limbs during the research period.

**General procedure**

All subjects received a detailed description of intended research and signed an informed consent form. Subjects were then screened for inclusion-exclusion criteria and performed the trunk flexibility test to ascertain suitability for inclusion. All volunteers were found suitable. Basic demographic data were collected using a self-administered questionnaire. Outcome measure tests were performed three times on each subject (evaluations E1-E3). The first baseline evaluation (E1) took place during the initial meeting, after confirmation of suitability. Immediately after performing the E1 evaluation, the KT was applied to the testing leg. Fifteen minutes later (time for tape’s adhesive to be activated) the second evaluation (E2) was performed. Forty-eight hours after applying the KT, the third evaluation (E3) was performed. Before each evaluation, subjects performed standardized five minutes of warm-up walking to precondition the lower extremity muscles. One tester performed all evaluations on the gastrocnemius group and another on the hamstring group. Both testers were trained in evaluations methods. At each evaluation, the tester was blinded to the outcomes of
previous evaluations.

The gastrocnemius group consisted of subjects in whom KT was applied to the gastrocnemius muscle. The following measurements were performed: passive SLR, knee extension angle test (KEA), weight bearing ankle dorsiflexion measurement, gastrocnemius peak force test and hamstring peak force test performed on the knee at a 90° and 45° flexion.

The hamstring group consisted of subjects in whom KT was applied to the hamstring muscles. The following measurements were performed: passive SLR; knee extension angle test (KEA); hamstring peak force test performed on the knee at 90° and 45° flexion; and the quadriceps peak force test performed on the knee at 90° and 45° flexion.

In both groups, ROM measurements were performed prior to the strength measurements. In peak force measurements, three trials were conducted for each subject and the mean value of the three trials was recorded for analysis.

**KT application**

KT application was performed by senior class physical therapy students (DL and EZ), who had received special training by an experienced certified instructor of the KT method (EV). After the initial training, the researchers developed a detailed protocol of KT applications. Then, using this protocol, the KT was applied by each student onto both legs of five volunteers (10 applications) who were not part of the study sample. These applications were supervised and if need be, corrected by a qualified instructor of the KT method. The study began only after both students’ KT applications were approved by instructor.

If the subject had substantial body hair, the area of application was shaved before
applying the KT. Before applying the KT onto the gastrocnemius muscles, the subject was asked to lie prone with the knee fully extended and feet hanging off the examination table (Figure 1). The researcher then applied a strip of cotton non-elastic sport tape ("white tape") around the testing foot, just distal to the navicular tuberosity, which helped anchor the KT. The subject's ankle was then held in full dorsiflexion and a "Y strip" of KT was applied to the testing leg. The tape was applied from the "white" tape anchor on the plantar surface of the foot to the insertion point of the Achilles tendon. The medial "Y" tail was applied along the medial border of the gastrocnemius and the lateral "Y" tail along the lateral border of the gastrocnemius with about 30% tension from resting length (distal to proximal). The end points were just above the popliteal fold. Lastly, another strip of non-elastic white tape was applied around the testing foot above the first white tape to complete anchoring of the KT. KT was applied to one leg only.

In the hamstring group, the tape was applied to the subject in a standing position, with trunk flexed in order to achieve initial hip flexion prior to tape application. The researcher applied an “I” strip of KT from the ischial tuberosity to the lateral aspect of the popliteal fossa on the lateral border of the hamstrings. A second “I” strip was placed from the ischial tuberosity to the medial aspect of the popliteal fossa on the medial border of the hamstrings (Figure 2). Tension of approximately 30% was applied to the tape during application.

According to Dr. Kase (Kase et al. 2003), the inventor of the KT, distal-to-proximal KT applications inhibit muscle function and proximal-to-distal applications facilitate muscle function. A recent randomized-control trial (Vercelli et al. 2012) comparing three different KT applications (distal to proximal, proximal to distal and
sham) on the quadriceps muscles found no increase nor decrease in maximal muscle strength compared to no taping. In our study, we chose the gastrocnemius application with tension applied from distal to proximal, and the hamstring application with tension applied from proximal to distal, since these applications are used most frequently.

**Straight leg rising (SLR)**

The subject lay supine on the examination table with both legs extended. The non-testing leg was stabilized by strapping the upper thigh. The ankle of the tested leg was stabilized in mid position by a gypsum splint. The subject was instructed to relax his/her muscles, not to resist and to signal the tester to stop when the muscles stretch became painful. The tester would then passively lift the testing leg by flexing the hip joint and keeping the knee fully extended. The end of the available ROM was determined by the subject’s tolerance to the stretch or by the tester who felt maximal stretch resistance. At the end of the available ROM, the hip joint angle was measured and recorded by the tester, who positioned the digital inclinometer on to the midpoint of the tibia. Intra-tester reliability for this test was high (interclass correlation (ICC)>0.97) (Davis et al. 2008).

**Knee extension angle test (KEA)**

The initial position and subject instructions were similar to the SLR test. While the non-testing leg was strapped, the tester passively lifted the testing leg by flexing the hip joint to a $90^\circ$ flexion, knee freely flexed. The tester then positioned a digital inclinometer on the anterior thigh just above the patella, asking the subject to grasp it. While keeping a $90^\circ$ flexion at the hip joint, the tester passively extended the testing knee. The end of the available ROM was determined by the subject’s tolerance of the stretch or by the tester who felt maximal stretch resistance. At the end of the available
ROM, the tester positioned another digital inclinometer on the midpoint of the anterior border of the tibia and recorded the KEA by subtracting the second inclinometer angle from the first. Intra-tester reliability for this test was high (ICC>0.99) (Davis et al. 2008).

**Weight bearing ankle dorsiflexion measurement**

The subject was placed in a standing position with both hands on a wall in front of him, positioning his testing leg behind the non-testing leg as far as possible. The testing foot was positioned parallel to a line on the floor, perpendicular to the wall. The subject then leaned forward until reaching a maximum stretch felt in the posterior area of the testing leg, while keeping the testing knee fully extended and the testing heel in contact with the ground. The non-testing leg remained in a comfortable position in order to maintain balance and not restrict dorsiflexion of the testing ankle. Lastly, the tester positioned the digital inclinometer on the midpoint of the anterior border of the tibia and recorded the measurement (intra-tester reliability for this test was moderate to high: ICC 0.77-0.91)(Munteanu et al. 2009).

**Quadriceps peak force evaluation**

The subject sat on the side of the examination table with the tested knee in a 90° flexion, strongly grasping the edge of the table for stability. The tester stood on the side of tested legs and stabilized the hydraulic push dynamometer against the anterior aspect of the inferior part of the tibia just above the malleoli. It was impossible for the tester to hold a dynamometer against the quadriceps. The other side of the dynamometer was stabilized by the wall of the room. The tester’s function was to hold the dynamometer at the correct position and to give the instructions to the subject. The subject then pressed as hard as he could on the dynamometer's pushing board, by extending his knee while gripping the bed
to stabilize his body. The maximal peak force was then recorded. The same procedure was executed again with the tested knee in a 45° flexion.

**Gastrocnemius peak force evaluation**

The examination table was placed between two walls with the headboard touching one of the walls, thus stabilizing the table. The tester then placed a hydraulic push/pull dynamometer (Baseline® hydraulic push/pull 500 lb. digital dynamometer) against the other wall and stabilized it. The subject lay supine with both feet reaching over the table. The testing leg was extended with maximal dorsiflexion of the ankle, while the metatarsals heads were situated against the dynamometer's pushing board. The subject then pushed the dynamometer pushing board as hard as he could, using the plantar flexion of the ankle while grasping the bed to stabilize his body. Achieved maximal force was recorded as gastrocnemius maximal peak force.

**Hamstring peak force evaluation**

The subject lay prone with the testing knee in a 90° flexion and stabilization straps on pelvic and distal thigh. The tester stood on the testing leg side and placed the hydraulic push dynamometer (microFET 2TM, Hoggan Health Industries, West Jordan, UT, USA) against the superior aspect of the Achilles tendon just above the malleoli and stabilized it. The subject then pushed the dynamometer's pushing board as hard as he/she could by flexing the knee while grasping the examination table to stabilize the body. Achieved maximal force was recorded as hamstring 90° maximal peak force. The same procedure was executed again with the testing knee in a 45° flexion. This method showed excellent intra-tester reliability (Ferro 2011)

**Data analysis**
Descriptive statistics were used to characterize the study sample. Repeated measurement ANOVA had been used to compare the strength and ROM measurements before, immediately after the KT application and two days later, still wearing the KT. Statistical analyses were conducted at a 95% confidence level. A p-value <0.05 was considered significant. To control for multiple comparison, the Bonferroni corrections were performed.

**RESULTS**

Thirty-six individuals (18 in the hamstring and 18 in the gastrocnemius groups 21 females and 15 males) participated in the study (Table 1). Mean age in both sample populations was 25.72±1.89 (range 22-29); and mean body mass index (BMI) was 21.73±2.10 (range 18.72-25.95). Nine individuals (25.00%) smoked and 22 (61.11%) participated in regular physical activities (Table 1).

Mean values (±SE) of all measurements taken are presented in Table 2. For each measurement and in both groups, follow up evaluations (E2 and E3) were compared (pairwise comparison in ANOVA) to the baseline evaluation (E1). P-values presented in the Table 2 are Bonferroni corrected.

In the gastrocnemius group, SLR (p=0.006) and ankle dorsiflexion ROM (p=0.006) measurements increased significantly 15 minutes after the KT application. This effect became insignificant after two days of wearing the KT. In addition, at E3 KEA ROM significantly increased (p=0.003). An increase in ROM at each studied joint was approximately 3°. In muscle peak force evaluations, only the gastrocnemius showed a significant increase in force (p=0.032) 15 minutes after applying the KT. However, two days after wearing the KT, both gastrocnemius and hamstrings (in a 45° flexion) showed a significant force increase (p-values <0.001 and 0.028,
The peak force increase of the gastrocnemius muscle ranged between 46 Newton 15 minutes after applying the KT to 137 Newton after two days of wearing the tape. Increase of peak force in the hamstrings, at 90° and 45°, was less prominent (between 12 and 20 Newton, respectively), after two days of wearing the tape.

In the hamstrings group, SLR significantly increased 15 minutes after KT application (p=0.025) with the effect becoming insignificant after two days of wearing KT (p=0.139). Total increase measured in SLR ROM was approximately 4.7°. KEA did not change significantly at E2 an E3. Muscle peak force evaluation showed no significant increase of hamstring force, at a 90° (p=1.000) and at a 45° flexion (p=0.195) 15 minutes after KT application. However, two days after wearing the KT, a significant increase in force (p=0.050 and p=0.010, correspondingly) was found in both measured angles. Quadriceps showed no change in muscle force in all tests (Table 2).

**DISCUSSION**

Research studies investigating the effects of KT are scarce. Most studies concentrate on KT’s effect on pain and other symptoms, or the uses of KT for treatment of certain clinical conditions (Akbas et al. 2011; Gonzalez-Iglesias et al. 2009; Hwang-Bo and Lee 2011; Kalichman et al. 2010; Kaya et al. ; Kaya et al. 2011; Saavedra-Hernandez et al. 2012; Thelen et al. 2008). We believe that it is essential to understand the effect of KT on the musculoskeletal system in normal in addition to pathological conditions, in order to perfect the application of KT in the clinic. If the KT application can influence the strength or flexibility of the healthy muscle, it can be used in cases of muscular imbalance which is important in the treatment and prevention of musculoskeletal pathology.
Evidence of KT’s effect on muscle strength is controversial. A recent, meta-analysis (Williams et al. 2012) found that 7 out of 10 studies showed a beneficial effect of KT application on muscle strength. Nevertheless, in three isokinetic studies, no significant effect on muscle strength was found when KT was applied to the quadriceps of healthy subjects (Fu et al. 2008; Lins et al. 2012; Vercelli et al. 2012). On the other hand, in a recent study of healthy participants investigating KT application on the biceps brachii (Fratocchi et al. 2012b), concentric elbow peak torque significantly increased even when compared to placebo taping.

The results of our study on the effect of KT application on muscle peak force can be divided into two parts: where KT was applied over the studied muscle and where KT was applied over the body segment adjacent to evaluated muscles. KT application over the gastrocnemius caused a significant immediate increase of its peak force. This is in accord with Huang et al (Huang et al. 2011) who found that KT applied to the gastrocnemius muscle immediately increased vertical ground reaction forces and EMG activity of the gastrocnemius while performing a vertical jump. In addition, the results of our study indicate for the first time, that the effects on muscle force increased two days after wearing KT. KT application over the hamstrings did not cause an immediate change of its peak force, in accord with Merino et al (Merino-Marban et al. 2011). However, after two days of wearing KT, hamstring peak force significantly increased. This effect should be replicated in other studies.

KT application on the gastrocnemius significantly increased hamstring peak force (after two days of wearing KT). This increase in force can probably be explained by the fascial connections between the gastrocnemius and hamstring muscles (Myers 2008; Tuncay et al. 2007).
On the other hand, KT application on the hamstrings did not change the peak force of the quadriceps. There are two possible explanations: 1) KT application does not change the force of quadriceps; 2) KT application on the antagonist muscle does not change the force of the muscle.

The majority of studies have evaluated only the immediate effect of kinesio taping rather than later effects (Briem et al. 2011; Fratocchi et al. 2012a; Gonzalez-Iglesias et al. 2009; Lins et al. 2013; Vercelli et al. 2012; Yoshida and Kahanov 2007). Slupik et al (Slupik et al. 2007) found similar results, 24 and 72 hours, after applying the KT on the vastus medialis of healthy subjects, which significantly increased recruitment of the muscle's motor units. In our study, hamstring peak force showed a tendency (non-significant) towards improvement immediately following KT application, however, measured peak force significantly improved only after two days of wearing the KT. Similarly, when KT was applied on the gastrocnemius, the change in the peak force of the hamstrings was significant only after two days of wearing KT. On the other hand, the significant effect of KT on gastrocnemius force was immediate and also additional improvement was demonstrated after two days of wearing KT. It is possible that different muscles react differently on KT application. This point should be tested in a future studies.

Very few trials examining KT include ROM as an outcome measure. Two trials [10, 18] involved pain-free ROM in an acute whiplash injury and shoulder pain, respectively. Both trials found increasing ROM after applying the KT. Akbaz et al (Akbas et al. 2011) evaluated the effects after applying additional KT versus exercise along in treating patello-femoral pain, and found a faster improvement in hamstring flexibility. However, the increase of ROM in patients with musculoskeletal morbidity can potentially
be attributed to a pain relieving effect of the KT application. The circumstances differ when healthy subjects are studied. Yoshida et al (Yoshida and Kahanov 2007), in a study of 30 healthy subjects, found that when applying KT over the lower trunk, an increase in active lower trunk flexion ROM may occur. Nelson et al. (Nelson 2011) in a study of 40 asymptomatic trained amateur cyclists found that the KT application above the rectus femoris significantly increased knee flexion. A small number of studies have evaluated the effect of KT application on the hamstrings (Merino-Marban et al. 2011; Merino et al. 2010). Merino et al (Merino et al. 2010) in a pilot study of 10 healthy triathletes found that KT application on hamstrings and low back immediately, significantly improved flexibility measured in the sit-and-reach test. However, in another study performed by the same authors (Merino-Marban et al. 2011) on 43 healthy university students, no difference was found in hamstring flexibility between no taping, immediately after application of sham or active KT application. However, this study had several methodological weaknesses. First, a manual goniometer, previously found to be an unreliable tool for measuring hip flexion (Nussbaumer et al. 2010) was used to evaluate the SLR angle. Second, during the SLR test, the pelvis was stabilized by a clinician not by a strap, which may have caused variation in hip stabilization.

In our study, a significant increase in ROM was found in all measurements. The SLR significantly increased immediately after the KT application on hamstrings or the gastrocnemius. Similarly, ankle dorsiflexion significantly increased immediately after the KT application on the gastrocnemius. These changes became insignificant after two days of wearing the KT, not because of the change in the mean value, but because of the high variance. Some insignificant improvement in KEA was seen immediately after KT application on the gastrocnemius, but it became significant only after two days of
wearing the KT. The mean ROM increase at the studied joint varied between 3.01° and 4.23°. However, there were seven subjects (19.4%) in whom SLR increased more than 10°. On the other hand, in some subjects, KT application did not change SLR or even slightly decreased it. The clinical meaning of these findings is still uncertain and future studies should examine its clinical impact.

One of the possible explanations accounting for the effect of KT application on muscular peak force and ROM, found in our study and on force sense found by others (Chang et al. 2010; Chang et al. 2012), is that the KT provides continuous tension to the skin, and thereafter to superficial and through skin ligaments, on deep fascia. Recently, investigations have demonstrated myofascial continuity and force transferee from muscle to muscle (Stecco et al. 2009; Turrina et al. 2013). In addition, it was shown that approximately 30% of muscle fibers inserted in the fascia envelope the muscle and inter-muscular septa (Stecco et al. 2007). The hypothesis that the effect of KT is due to fascial unloading has been proposed and advocated (O’Sullivan and Bird 2011). In addition, KT has been shown to effectively treat plantar fasciitis (Tsai et al. 2010) and meralgia paresthetica (Kalichman et al. 2010). In both studies the effect, most probably, can be attributed to fascial unloading. How the different changes in fascial tension (e.g. amount and direction of tension) influence muscle strength and elasticity should be established in future studies. It is also possible that different muscles (uni- vs. bi-articular, tonic vs. phasic, etc.) will react differently to the change of fascial tension by the KT application.

There were a few study limitations. Firstly, there was no comparison with a sham taping. Therefore, part of the increase in muscle force and ROM at the follow up evaluations (E2 or E3) can be due to a placebo effect. Second, the order of evaluations
was not random; therefore, at least part of the effect can be attributed to a motor learning of the task, so called “testing effect”. However, if the change in peak force and ROM was attributed only to a placebo effect, we would most probably see more significant improvements the in quadriceps force or in KEA ROM; if the change was attributed only to “testing effect”, we would expect, for example, the more significant increase in SLR and ankle dorsiflexion at E3. In addition, the researchers who performed the outcome tests were not blinded to presence/absence of KT or to evaluation order. Absence of blinding may potentially cause an expectancy bias, where the researchers’ expectations/beliefs cause them to unconsciously influence the participants. Although we tried to design the tests as objective and uniform as possible, there was a risk of measurement bias.

**CONCLUSIONS**

In study, we found that KT application on the gastrocnemius caused a significant increase of its peak force immediately and after two days of wearing the KT. KT application over the hamstrings or gastrocnemius, did not cause an immediate change of hamstring peak force, however, after two days of wearing KT, hamstring peak force, significantly increased.

A significant increase in ROM was found in all measurements. SLR and ankle dorsiflexion significantly increased immediately after application of KT, but KEA improved significantly only after two days of wearing KT on the gastrocnemius. It is possible that different muscles react differently when KT is applied; and on occasion, the effect of KT application is detected only after some time.

Additional studies should be conducted to evaluate the effect of KT application on the ROM and muscle force. The design of these studies should include sham taping
application and randomization of KT application order. The subjects should wear clothes above the area of KT application. This way the assessor will be blinded to the presence or absence of KT or its application.
Acknowledgements

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**Table 1** Descriptive statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>Gastrocnemius group (N=18)</th>
<th>Hamstrings group (N=18)</th>
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<tr>
<td><strong>Mean± SD</strong></td>
<td><strong>Mean± SD</strong></td>
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</tr>
<tr>
<td>Age</td>
<td>25.56±2.09</td>
<td>25.89±1.71</td>
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<tr>
<td>BMI</td>
<td>21.68±1.93</td>
<td>21.77±2.31</td>
</tr>
<tr>
<td>Sex (females)</td>
<td>12 (66.7%)</td>
<td>9 (50.0%)</td>
</tr>
<tr>
<td>Smoking</td>
<td>4 (22.2%)</td>
<td>5 (27.8%)</td>
</tr>
<tr>
<td>Regular physical activity</td>
<td>10 (55.6%)</td>
<td>12 (66.7%)</td>
</tr>
</tbody>
</table>

SD: standard deviation; BMI: body mass index
Table 2 Comparison (ANOVA) of range of motion (ROM) and muscle strength parameters (Bonferroni corrected).

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Hamstrings group (Mean ± SE)</th>
<th>Gastrocnemius group(Mean ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (E1)</td>
<td>E2</td>
</tr>
<tr>
<td><strong>Range of motion</strong></td>
<td>SLR</td>
<td>62.82°±2.58</td>
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<tr>
<td>(ROM)</td>
<td></td>
<td>p=0.025</td>
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<td>KEA</td>
<td>39.68°±2.75</td>
<td>36.98°±1.96</td>
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<td></td>
<td></td>
<td>p=0.656</td>
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<td>Ankle</td>
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<td>-</td>
</tr>
<tr>
<td>dorsiflexion</td>
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<tr>
<td><strong>Muscle strength</strong></td>
<td>Quadriceps</td>
<td>350.97±28.44</td>
</tr>
<tr>
<td>45° (N)</td>
<td></td>
<td>p=0.294</td>
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<tr>
<td></td>
<td>Quadriceps</td>
<td>435.35±36.74</td>
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<tr>
<td>90° (N)</td>
<td></td>
<td>p=1.000</td>
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<tr>
<td>Hamstrings</td>
<td>227.97±21.70</td>
<td>243.18±24.18</td>
</tr>
<tr>
<td>45°(N)</td>
<td></td>
<td>p=0.195</td>
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<tr>
<td>Muscles</td>
<td>90° (N) 181.81±15.82</td>
<td>180.87±14.06</td>
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<tr>
<td>Hamstrings</td>
<td>180.78±14.06 p=1.000</td>
<td>180.87±14.06</td>
</tr>
<tr>
<td>Gastrocnemius (N)</td>
<td>- p=0.050</td>
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SLR: straight leg raising; KEA: knee extension angle; SE: standard error; E: evaluation
Captions to illustrations

**Figure 1.** Kinesio tape application on the hamstrings.

**Figure 2.** Kinesio tape application on the gastrocnemius.