Kinesio Taping® does not alter neuromuscular performance of femoral quadriceps or lower limb function in healthy subjects: Randomized, blind, controlled, clinical trial

Caio Alano de Almeida Lins, Francisco Locks Neto, Anita Barros Carlos de Amorim, Liane de Brito Macedo, Jamilson Simões Brasileiro

**A R T I C L E   I N F O**

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**A B S T R A C T**

The aim of this study was to analyze the immediate effects of applying Kinesio Taping® (KT) on the neuromuscular performance of femoral quadriceps, postural balance and lower limb function in healthy subjects. This is a randomized, blind, controlled, clinical trial, where sixty female volunteers (age: 23.3 ± 2.5 years; BMI: 22.2 ± 2.1 kg/m²) were randomly assigned to three groups of 20 subjects each: control (10 min at rest); nonelastic adhesive tape (application over the rectus femoris, vastus lateralis and vastus medialis muscles); and KT (KT application over the same muscles). All individuals were assessed for single and triple hops, postural balance (by baropodometry), peak concentric and eccentric torque and electromyographic activity of vastus lateralis, before and after interventions. No significant differences in electromyographic activity of the VL or concentric and eccentric knee peak torque were recorded, between groups and initial and final assessment in any of the three groups. We also observed no significant alteration in single and triple-hop distance and one-footed static balance between the three groups. Application of KT to RF, VL and VM muscles did not significantly change lower limb function, postural balance, knee extensor peak torque or electromyographic activity of VL muscle in healthy women.

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1. Introduction

Physically active individuals, who engage in recreational, amateur or professional level activities, constantly seek recourses to enhance their muscle performance.

Within this context, the Japanese chiropractor Kenso Kase developed Kinesio Taping® (KT), an elastic bandage with unique characteristics applied over or around muscles to provide functional support (Kase et al., 1996, 2003). The technique consists of a thin tape, which is elastic and can be stretched up to 50% of its original length, resulting in less restriction, when compared to conventional tapes (Kase et al., 1996, 2003). It is applied to decrease pain and edema, increase joint stability and improve muscle performance (Kase et al., 2003; Thelen et al., 2008).

The mechanisms by which KT application would achieve the expected result have not been fully elucidated. Some researchers state that its direct application on the skin activates a number of cutaneous mechaceptors, which would relieve pain directly through a gate-control theory. Furthermore, due to its adhesive and elastic characteristics, the KT bandage could increase interstitial space, favoring better blood and lymphatic flow (Kase et al., 2003; Thelen et al., 2008).

Other researchers (Murray and Husk, 2001; Cools et al., 2002; Halseth et al., 2004; Macgregor et al., 2005) propose to explain the possible mechanism that increases muscle activity during KT and nonelastic tape application, among which is neurofacilitation. However, these studies are still scarce and controversial.

The effect of KT application has been the target of investigations assessing its influence on balance and lower limb function, as well as muscle activation and force, but with conflicting results (Murray, 2000; Murray and Husk, 2001; Osterfues, 2004; Fu et al., 2008;...
Firth et al., 2010; Aytar et al., 2011). For example, Vithoulka et al. (2010) demonstrated that KT, applied to the femoral quadriceps, increased peak eccentric torque in healthy non-athlete women. However, Fu et al. (2008) showed that KT did not influence muscle force, when applied to the quadriceps of healthy athletes.

In light of the scarcity of research on assessing the effect of KT on neuromuscular performance of the femoral quadriceps and lower limb function, the present study aimed to analyze the immediate effects of KT application, clustering different variables individually assessed in previously published articles: electromyographic activity of the VL, knee concentric and eccentric extensor torque, balance and lower limb function in healthy women. We hypothesized that subjects submitted to KT application would exhibit better neuromuscular and functional performance, when compared to control and non-elastic tape groups.

2. Materials and methods

2.1. Subjects

Sixty healthy female volunteers, mean age of 23.3 ± 2.5 years and body mass index (BMI) of 22.2 ± 2.1 kg/m² took part in the study. All subjects were between 18 and 28 years old, recreationally active (Pincivero and Gandaio, 2003), with no history of osteo-myarticular lesion or surgery in the lower limbs in the previous six months, non-corrected neurological, vestibular, visual and/or hearing impairments, in addition to displaying no allergy to adhesive material. Individuals experiencing pain during collection procedures or who did not perform exercises as instructed by the researchers would be excluded. However, based on these criteria, none of the subjects were excluded.

Participants were recruited among students of a local university, by non-probabilistic convenience sampling, and gave informed consent, according to Resolution 196/96 of the National Health Council, after being informed of the study aims. The study was approved by the local Research Ethics Committee under protocol number 604/11 and in accordance with CONSORT recommendations.

2.2. Procedures

Initially, all volunteers warmed up on a stationary bicycle (Ergo-Fit®, Ergo Cycle 167, Pirmasens, Germany) for 5 min, with the seat adjusted to the height of the greater trochanter and a load of 20 W. Immediately after, we assessed lower limb function, one-footed static balance, concentric and eccentric peak knee extensor torque and electromyographic activity of the VL. Following this assessment, volunteers were randomly distributed, using the website www.randomization.com, into one of three groups of 20 individuals each. Groups were color coded to allow blind analysis by a third researcher. The control group underwent initial assessment, remaining at rest for 10 min, which was followed by final evaluation.

After initial assessment, the kinesio taping (KT) group was submitted to KT application (kinesio tex gold®) to rectus femoris (RF), VL and VM muscles in the dominant limb, longitudinally, from the proximal to the distal, assuming the same position adopted in the KT group. Following intervention, subjects underwent a second evaluation, identical to the first.

2.2.1. Assessment of lower limb function

We conducted single and triple hop tests, considered testing measures of strength and functional stability (Keays et al., 2000). Initially, subjects were familiarized with the tests, which were repeated once with the dominant limb. They were instructed to hop with no support from the contralateral limb as naturally as possible.

In the first test (single hop), subjects were encouraged to hop as far as possible on the dominant limb. Hallux—hallux distance was the measure used. In the second test (triple hop) they were instructed to perform three consecutive hops on the dominant limb, as far as possible, concluding the hop on the same limb. The total distance of the three consecutive hops was recorded (Reid et al., 2007). Individuals wore no footwear and the distance was measured with a metric tape. Data were normalized as a function of the height of each subject (hop distance/height × 100) in order to compare hop distances.

Each hop was performed twice and the better result recorded. For the hop to be considered valid subjects had to remain in balance for 2 s after completing it and the contralateral or upper limbs could not touch the ground. If any of the above occurred the test was repeated. A 1-min rest period was allowed between each test.

The use of two types of hops is justified by the fact that they incorporate a range of principles involved in controlling the dynamic stability of the limb. The single hop test differs from the triple hop test in that it assesses different aspects related to sensory-motor control, such as direction change, speed, acceleration/deceleration and rebound (Reid et al., 2007).

2.2.2. Determination of one-footed static balance

A 40 cm × 40 cm computerized baropodometer (Eclipse 3000, Guy-Capron® SA, França), was used to collect one-footed static balance data. Subjects were standing on the platform of the
baropodometer with support on the dominant leg and knee flexed at 20°, as measured by a universal goniometer. Individuals were instructed to keep their head in the neutral position, staring at a fixed point, spine erect, with upper limbs supported on the hip. The non-dominant lower limb remained with the hip at 0° and knee flexed at 90°. Data acquisition time was 10 s, using 200 frames per second. Subjects were assessed twice, with the best result considered for analysis (Ageberg et al., 2005). A 1-min rest period was allowed between each test and the variables analyzed were displacement amplitude and displacement velocity of the pressure center in the antero-posterior and latero-lateral directions.

2.2.3. Assessment knee extensor torque
An isokinetic dynamometer (Biodex Multi-Joint System 3®, Biodex Biomedical System Inc, New York, USA) calibrated weekly, according to manufacturer's recommendations, was used for this assessment.

Subjects were seated in the dynamometer chair, with the thigh of the non-dominant leg, as well as the pelvic and thorax regions secured by a belt. The rotation axis of the dynamometer was aligned with the lateral epicondyle of the femur. The lever arm was then adjusted in the distal region of the leg and fixed 5 cm above the medial malleolus of the dominant limb. The gravity correction factor was applied by the dynamometer itself, which is corrected for the weight of the dominant leg relaxed at 30° of knee flexion. All adjustments were in accordance with Dvir recommendations (2004).

Dynamometric assessment was carried out using five maximum concentric and eccentric knee extensor contractions at 60°/s. Concentric assessment started with the knee flexed at 90°, concluding with complete extension, while eccentric evaluation considered knee flexion between 30° and 90°. Peak torque normalized for body weight was recorded for both assessments and expressed in percentage (PT/BW × 100).

Verbal encouragement was given during the entire dynamometric test, as well as visual feedback on the computer monitor. Subjects were familiarized with the equipment through submaximal contractions, before each assessment.

2.2.4. Electromyographic activity of the VL
The electromyographic signal was captured by a four-channel signal conditioner module (EMG System do Brasil®) with a 12-bits analogical-digital (A/D) converter (CAD, 12/36-60K). The device has a common-mode rejection ratio (CMRR) > 80 Db, with sampling frequency configured at 2000 Hz and the signal was filtered between 20 and 500 Hz. Signals were amplified 1000 times, 20 times in the electrodes and 50 times in the converter. The device was linked by a battery and connected to a laptop, which received the signal and stored it in a file. EMGLab software (EMG System do Brasil®, Brasil) was used for digital analysis of the signals.

To capture electromyographic activity of the VL muscle, the skin of subjects was shaved and cleaned with 70% alcohol. We used a self-adhesive surface electrode (Ag/AgCl, Noraxon®, USA), with single differentials and inter-electrode distance of 2 cm, positioned on the VL muscle following SENIAM recommendations (Hermens et al., 2000). The reference electrode (monopolar, self-adhesive - Noraxon®, USA), in turn, was placed on the tibial tubercle of the same limb.

Electromyographic activity of the VL muscle was recorded simultaneously to knee extensor torque assessment. Thus, to analyze root mean square (RMS) during concentric and eccentric evaluation, we considered the mean electromyographic signal recorded over 2 s of the highest torque of five recorded on the isokinetic dynamometer, with RMS normalized by maximum voluntary isometric contraction (MVIC), according to Deluca recommendations (1997).

2.2.5. Statistical analysis
The Statistical package SPSS 17.0 was utilized for all statistical analyses. Study power was calculated prospectively, obtaining a type 1 error of 0.05 and type 2 error of 0.20. It was estimated that 18 subjects would be needed in each group to detect a difference around 10%, with a power of 80%. Values for knee extensor torque before and immediately after intervention was utilized in order this calculus.

The Kolmogorov–Smirnov (K–S) test was applied to check for normality of data. All variables exhibited normal distribution. Descriptive statistics were used to derive mean ± SD for all variables. Repeated measures one-way analysis of variance (ANOVA) was used to determine intergroup and intragroup differences before and after interventions. A 5% significance level was used in statistical analysis.

3. Results
3.1. Electromyographic activity of the VL and knee extensor torque
Electromyographic activity showed no significant alteration between initial and final assessments for concentric and eccentric RMS of the VL, in any of the study groups. Similarly, no differences were recorded between initial and final evaluations in the three groups for the variable concentric and eccentric PT/BW. Moreover, we observed no significant difference between the three groups (Table 1).

3.2. Lower limb function and one-footed static balance
In relation to lower limb function, Table 2 shows no significant alteration in the single and triple hop for the three groups. In regard to one-footed static balance, no significant differences were found between initial and final assessments for the variables antero-posterior amplitude, latero-lateral amplitude, antero-posterior velocity and latero-lateral velocity in the three groups. Nor was any significant difference detected between the three groups (Table 2).

<table>
<thead>
<tr>
<th>Variables (n = 20)</th>
<th>Control Mean ± SD</th>
<th>Nonelastic TAPE Mean ± SD</th>
<th>KT Mean ± SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>RMS conc (%)</td>
<td>112.2 ± 21.5</td>
<td>110.8 ± 25.7</td>
<td>104 ± 17.1</td>
<td>109.2 ± 18</td>
</tr>
<tr>
<td>RMS ecc (%)</td>
<td>95 ± 14.4</td>
<td>89.2 ± 22.6</td>
<td>91 ± 26.3</td>
<td>96.2 ± 29</td>
</tr>
<tr>
<td>PT/BW conc (%)</td>
<td>218.2 ± 57.5</td>
<td>221.3 ± 46.8</td>
<td>220.6 ± 50.5</td>
<td>218.4 ± 49</td>
</tr>
<tr>
<td>PT/BW ecc (%)</td>
<td>307.3 ± 61.2</td>
<td>286.3 ± 49.4</td>
<td>310 ± 45.2</td>
<td>298 ± 48</td>
</tr>
</tbody>
</table>
Table 2
Means and standard deviations of the variables: single-hop and triple-hop distance (normalized for height); displacement amplitude and displacement velocity antero-posterior (A/P) and latero-lateral (L/L) of the center of pressure, before and after applying the protocol in the three groups (control, nonelastic adhesive tape and KT).

<table>
<thead>
<tr>
<th>Variables (n = 20)</th>
<th>Control Mean ± SD</th>
<th>Noneelastic tape Mean ± SD</th>
<th>KT Mean ± SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Single hop (%)</td>
<td>76.1 ± 15.3</td>
<td>80 ± 14.2</td>
<td>76 ± 9.2</td>
<td>79.4 ± 9.2</td>
</tr>
<tr>
<td>Triple hop (%)</td>
<td>227.6 ± 38.9</td>
<td>230 ± 47.4</td>
<td>223 ± 28</td>
<td>228.7 ± 31.2</td>
</tr>
<tr>
<td>Amplitude A/P (mm)</td>
<td>15.6 ± 6.1</td>
<td>15.3 ± 5.1</td>
<td>16.6 ± 7.6</td>
<td>19.8 ± 8.2</td>
</tr>
<tr>
<td>Amplitude L/L (mm)</td>
<td>12.1 ± 4.7</td>
<td>13.4 ± 5.7</td>
<td>10.7 ± 5.5</td>
<td>12.7 ± 6.3</td>
</tr>
<tr>
<td>Velocity A/P (mm/s)</td>
<td>10.9 ± 4.4</td>
<td>9.5 ± 2.7</td>
<td>9.7 ± 3.0</td>
<td>9.6 ± 2.8</td>
</tr>
<tr>
<td>Velocity L/L (mm/s)</td>
<td>5.8 ± 2.7</td>
<td>5.3 ± 2.2</td>
<td>5.5 ± 3.4</td>
<td>5.6 ± 1.5</td>
</tr>
</tbody>
</table>

4. Discussion

In the present study, no significant differences in electromyographic activity of the VL or peak concentric and eccentric knee torque at 60°/s were recorded, between groups and initial and final assessment in any of the three groups.

Briem et al. (2011) assessed the effect of KT on the level of activation of the fibularis longus muscle during a “sudden disturbance” of the ankle in 51 healthy athletes, finding no significant alterations in this variable. On the other hand, Hsu et al. (2009) reported that KT application provoked a significant increase in the electromyographic activity of the lower trapezius muscle during shoulder abduction in 17 athletes, underscoring that they exhibited shoulder impingement syndrome.

A number of theories attempt to explain how KT increases neuromuscular recruitment, including: 1) the tactile stimulus provided by KT activates cutaneous receptors, facilitating motor unit activation; 2) KT applied directly to the skin increases interstitial space, enhancing blood flow and possibly favoring a rise in muscle activation (Kase et al., 2003).

However, in the present study, no significant alterations were detected in the electromyographic activity of the VL muscle, indicating that tactile stimulation promoted by KT was not sufficient to change recruitment of this muscle. Corroborating the results of the present research, experimental studies (Fu et al., 2008; Vithoukla et al., 2010) have indicated that KT applied directly to the femoral quadriceps has no immediate effect on peak torque in healthy subjects.

We also observed no significant alteration in single-hop and triple-hop distance between the three groups. Likewise, the variables displacement amplitude and displacement velocity of the antero-posterior and latero-lateral pressure center showed no significant difference between groups and initial and final values in the three study groups.

Similar findings were reported by Firth et al. (2010), who found no alteration in single-hop distance, in either healthy subjects or those with Achilles tendinopathy, after KT application to the ankle. Huang et al. (2011) analyzed vertical hop height 30 min after KT application to the ankle, in healthy subjects, also finding no significant alteration. With respect to static balance, Aytar et al. (2011) detected an improvement during KT application to the femoral quadriceps in women with patellofemoral pain syndrome. Few studies have assessed lower limb function and one-footed static balance after KT application, hindering analysis of the real effects of this technique on these variables.

The present study showed no significant alteration in the single and triple hop and one-footed static balance for the three groups. KT application only to femoral quadriceps muscles may not have been responsible for altering these variables, given that other muscles and joints such as the hip and ankle are also involved in these activities.

Our findings indicate that applying KT to femoral quadriceps does not alter neuromuscular performance or lower limb function. These findings can be explained by a number of hypotheses. First, our sample was composed of healthy subjects, which leads us to believe that KT applied to this population had no effect whatsoever, since they exhibited no neuromuscular dysfunctions that could be minimized by applying this technique.

Second, it is questionable whether applying a bandage to the skin surface can alter the population of recruited motor units, thereby enhancing neuromuscular performance. Moreover, this study suggested that, whether through nonelastic tape or KT applied over the same area of skin did nothing to change the variables explored.

Finally, the hypothesis that KT would produce an increase in blood flow and possibly favoring a rise in muscle activation, was not proven, suggesting that the tension produced from the bandage is not sufficient to promote these alterations.

5. Conclusion

The results of the present study suggest that KT application to RF, VL and VM muscles is not capable of altering lower limb function, one-footed static balance, peak knee extensor torque or activation amplitude of the VL muscle, in healthy women. Moreover, the application of nonelastic adhesive tape over the same area of skin did not significantly change these variables. Finally, it is important to remind that the findings presented here are limited to active healthy women engaging in recreational physical activity. It is therefore suggested that further studies be conducted to assess the acute and chronic effects of KT on the function, balance and neuromuscular performance of patients under a rehabilitation program.

References


