The effect of kinesiology tape on knee proprioception in healthy subjects

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Summary *Background:* Kinesiology tape can improve athletic performance; however, due to cutaneous stimulation its application can have an influence on proprioception.
Objectives: To determine the effects of kinesiology tape on knee proprioception applied to quadriceps, namely in the joint position sense (JPS) and in the threshold to detect passive movement (TTDPM), both immediately after and 24 h after its application.
Methods: Thirty young healthy participants were randomly divided into experimental and control group. In the experimental group, a kinesiology tape on the quadriceps muscle was applied. The JPS and the TTDPM of the knee was assessed before, immediately after and 24 h after the kinesiology tape intervention.
Results: No significant differences were found in the assessment made before intervention. The *Friedman Test* showed that kinesiology tape had no influence on JPS in either group over time ($p > 0.05$). However, the TTDPM decreased significantly immediately after and 24 h after its application ($p < 0.05$).

KEYWORDS Taping techniques; Sensorimotor system; Joint position sense; Threshold to detect passive movement

Introduction

Kinesiology tape is a relatively new method frequently used in clinical practice and sport environments to prevent and treat a wide variety of musculoskeletal disorders, sports injuries, and inflammatory conditions. This technique involves an application of a thinner and more elastic tape than the conventional athletic tape which is applied to the target muscle in a stretched position with enough tension to create skin convolutions (Kase et al., 2003). According to the authors, this elevation of the epidermis reduces the pressure on the mechanoreceptors situated below the dermis and, as a result, reduces the nociceptive stimuli. Therefore, kinesiology tape speeds healing by slightly lifting skin away from sore or injured tissues, improves blood flow and lymphatic drainage, and supports injured joints and muscles without restraining their range of motion (Morris et al., 2013).

Kinesiology tape could improve athletic performance at a higher rate in comparison to white athletic tape by amplifying proprioception (Bicici et al., 2012). Theoretically, the mechanisms to explain its effect on performance and motor control should be related to the increase of afferent information due to the stimulation of the cutaneous mechanoreceptors, such as Meissner corpuscle end-organs, Pacinian corpuscle end-organs, hair follicle end-organs and some free nerve endings (Riemann and Lephart, 2002). The mechanical effect on segment positioning induced by the adhesive material would also interfere in the afferent inputs from the articular and muscular receptors, leading to improvement of the sensory-motor system.

The great importance of the muscle reflexes, muscle contractions, and joint stabilization as a response to the neural cumulative input to the central nervous system, described as proprioception, is well known (Garsden and Bullock-Saxton, 1999). In fact, changes in afferent stimuli from different areas of the body have interference in conscious and unconscious sensations, automatic control of movement, balance, postural control, joint stability and motor control (Callaghan et al., 2002; Ribeiro and Oliveira, 2010).

The afferent inputs due to skin stretching have an important role in the detection of joint movement and position as a result of the cutaneous mechanoreceptors stimulation (Riemann and Lephart, 2002). Moreover, the increase in proprioception through increased stimulation to cutaneous mechanoreceptors by kinesiology tape was initially suggested by Murray in 2000 (Murray, 2000).

However, this enhancement of proprioception induced by kinesiology tapes has not been supported by others (Halseth et al., 2004). In fact, these authors carried out a study aiming to determine whether Kinesio Taping® applied on the anterior and lateral portion of the ankle enhances ankle proprioception when compared to the non-taped ankle, and found no effect of this intervention on ankle joint position sense.

In addition to the current evidence showing that kinesiology tape does not have beneficial effects on pain when compared with "sham" treatment, recent systematic reviews also found insufficient evidence or some anecdotal support of kinesiology tape as a method to improve the sensory-motor, prevention or treatment of musculoskeletal injuries (Bassett et al., 2010; Kalron and Bar-Sela, 2013; Morris et al., 2013; Mostafavifar et al., 2012; Parreira et al., 2014; Williams et al., 2014).

Therefore, as there is yet insufficient evidence on the effect of kinesiology tape on proprioception, the aim of this study is to determine its effect on knee proprioception, namely in the joint position sense (JPS) and in the threshold to detect passive movement (TTDPM), immediately after and 24 h after application on healthy subjects.

Methods

Participants

Thirty healthy participants between the ages of 18 and 25 years old were recruited for the study through an advertisement displayed in a health school. Although none of them were athletes, they were physically active. The anthropometric characteristics of the sample were: Male ($n = 15$), aged 21.3 $\pm$ 1.4 y, height 176.8 $\pm$ 6.6 cm, and body mass 24.3 $\pm$ 4.2 kg/m^2; Female ($n = 15$), aged 21.2 $\pm$ 1.2 y, height 162.7 $\pm$ 5.5 cm, and body mass 22.7 $\pm$ 3.8 kg/m^2.

None of the participants had a history of knee injury or any orthopaedic or neurologic dysfunctions in the lower limbs (Torres et al., 2010), or surgery to knees in the period of one year before the study (Campolo et al., 2013). Moreover, the participants had not been involved in any intense exercise program for three weeks prior to the study.

All procedures were approved by the local Ethics Committee in accordance with the Helsinki Declaration prior to the commencement of this study. Furthermore, all participants gave their written informed consent prior to participating.

Procedures

The sample was randomly divided into two groups: the experimental group ($n = 20$; 10 women and 10 men) and the control group ($n = 10$; 5 women and 5 men). To allocate participants into the groups, an opaque bag was used.

The proprioception was assessed in three moments in both groups: "*before taping*", "*immediately after taping*", and "*24 h after taping*". The intervention in the experimental group consisted of a kinesiology tape placed on the quadriceps muscle in the dominant leg, whereas in the control group no intervention was performed. The same researcher collected all measures and a skilled physiotherapist applied the kinesiology tape.

Interventions: kinesiology tape/control

The blue kinesiology tape (CureTape, FysioTape B. V., SW Enschede, Netherlands) was used in the experimental groups. Before applying the kinesiology tape, the anterior thigh was shaved and cleaned with alcohol. The tape was placed with the quadriceps muscle in maximum stretch

Figure 1 Kinesiology tape applied on the quadriceps muscle.

position as shown in Fig. 1; the participant was in prone position on a treatment table, hip in neutral position and the knee in a flexed position.

The tape had the "Y" formation and was applied from the origin (anterior inferior iliac spine) to the insertion (tibial anterior tuberosity) in order to stimulate the sensory mechanoreceptors. Moreover, the tension was placed between 50 and 75% in the middle without any stretch in the extremities (Kenzo et al., 2003). The intervention was always performed by the same physiotherapist, who was trained and experienced in working with kinesiology taping in a sports environment.

Assessment of the proprioception

The knee proprioception was evaluated with an isokinetic dynamometer (Biodex System 3, Medical Systems, Inc., Shirley, NY, USA) and consisted of the assessment of the JPS and the TTDPM. Drouin et al. (2004) showed that the Biodex System 3 isokinetic dynamometers is a reliable tool for the measurement of an angular position, isometric torque, and slow to moderately high velocities of the torque, with high intra-class correlation coefficients (ICC 2,K = 0.99 for each variable) (Drouin et al., 2004).

Participants were familiarized with the assessment protocol one day prior to their initiation by the main researcher. The assessment of JPS and TTDPM followed the procedures described by others (Torres et al., 2010). Briefly, the assessment of JPS was performed at 30 and 60 degrees of knee flexion in the dominant leg and involved passive positioning and active repositioning (passive—active test).

The position of the participants in the dynamometer followed the guidelines of the manufacturer's instructions (Biodex Pro Manual, Applications/Operations, Biodex Medical Systems, Inc., Shirley, NY). Therefore, they were seated in the isokinetic dynamometer chair with 100° of hip flexion, with their eyes closed and wearing headphones. Moreover, to reduce cutaneous sensory information, an air cushion above the leg with a pressure of 40 mmHg was used.

The dynamometer moved the knee slowly in the extension direction at 10° per second, stopping either at 30° or at 60° and remaining in this position for 5 s, with the aim of memorizing the target angle. After this period of time, the knee returned to the initial position and participants were asked to achieve this angle as best as possible by pressing the hold button that they had in their hand to stop the dynamometer lever arm. These procedures were repeated three times for each position in a random way. The absolute error of the repositioning was calculated through the difference between the target angle and the mean of the three angles chosen by the participants and used as a proprioceptive marker.

The TTDPM was performed with participants in the same conditions as assumed in the assessment of the JPS. However, the participants' knee was positioned at 30 degrees or 60 degrees of flexion and the dynamometer moved passively at a speed of 0.25° per second towards extension. The participants were instructed to press the "button" when they felt movement in the knee, which was randomly started by the researcher in the subsequent 30 s. Three trials from each initial position were performed and the average of the degrees necessary to detect the movement in each of them was used to assess the TTDPM.

Statistical analysis

The distribution of all variables was examined using the *Shapiro—Wilk* test and as the normality of the distribution was not found, the data was reported as a median interquartile interval. Moreover, the *Mann—Whitney* test was used to analyse differences between groups and the *Friedman* test was used to detect differences in intervention across test attempts; when significant differences were found among moments, the *Wilcoxon's Signed Rank Tests* were applied to discriminate between those differences.

The statistical analysis of data was performed using the software *Statistical Package for the Social Sciences* version 21.0 (IBM Corporation, Armonk, New York, USA). The level of significance was set at $p < 0.05$.

Results

All 30 subjects reached the end of the study. Their mean (SD) physical characteristics are presented in Table 1. No significant differences were found between groups for the age, height and body mass index variables ($p > 0.05$).

The values of active and passive JPS and TTDPM obtained *"before taping"*, were similar between groups (Tables 2 and 3). Furthermore, the results of JPS between groups remained in the other two assessment moments with no significant differences. Thus, the experimental group

Table 1 Anthropometric characteristics of the sample.

	Control group	Experimental group	p
Age (years)	21.80 (±1.14)	20.95 (±1.31)	0.093
Height (cm)	167.80 (±6.03)	170.70 (±10.62)	0.432
Body mass index (kg/m^2)	24.24 (±3.91)	23.16 (±4.12)	0.495

Table 2 Comparison of joint position sense recorded before, immediately and 24 h after kinesiology tape intervention. Absolute values (degrees) are expressed as median (interquartile interval); ($p < 0.05$).

Joint position sense		Groups	Before taping	Immediately after taping	24 h after taping	*Friedman test*
Active	At 30 degrees of knee flexion (degrees)	Experimental	5.77 (3.05)	4.00 (1.92)	3.33 (5.67)	0.197
		Control	6.00 (2.75)	4.17 (3.67)	6.67 (4.75)	0.095
	Mann–Whitney U test		0.196	0.681	0.198	
	At 60 degrees of knee flexion (degrees)	Experimental	3.67 (3.83)	3,50 (1.92)	4.00 (3.83)	0.771
		Control	5.33 (5.75)	5.00 (4.25)	4.00 (3.42)	0.202
	Mann–Whitney U test		0.559	0.120	0.681	
Passive	At 30 degrees of knee flexion (degrees)	Experimental	5.17 (5.25)	5.17 (6.83)	6.17 (5.58)	0.761
		Control	6.00 (5.08)	5,33 (5.42)	5.50 (4.83)	0.283
	Mann–Whitney U test		0.619	0.948	0.448	
	At 60 degrees of knee flexion (degrees)	Experimental	2.83 (2.42)	3.33 (2.67)	3.17 (5.08)	0.843
		Control	8.50 (5.92)	5.83 (5.17)	4.83 (3.58)	0.368
	Mann–Whitney U test		0.049	0.475	0.779	

Table 3 Comparison of threshold to detect passive movement before, immediately and 24 h after kinesiology tape intervention. Absolute values (degrees) are expressed as median (interquartile interval); ($p < 0.05$).

Threshold to detect passive movement	Groups	Before taping	Immediately after taping	24 h after taping	*Friedman test*
At 30 degrees of knee flexion (Degrees)	Experimental	2.33 (1.33)	1.00 (0.67)[a]	1.33 (1.67)[a]	0.005
	Control	1.83 (1.37)	1.33 (1.08)	1.17 (1.00)	0.060
Mann–Whitney U test		0.243	0.307	0.894	
At 60 degrees of knee flexion (Degrees)	Experimental	2.00 (1.50)	1.33 (1.42)[a]	1.00 (0.87)[a]	0.017
	Control	1.83 (1.92)	2.33 (2.54)	1.17 (0.92)	0.131
Mann–Whitney U test		0.913	0.078	0.960	

[a] Wilcoxon's signed rank tests showed statistically significant differences with respect to the value "*before taping*" ($p < 0.05$).

had no influence on this component of proprioception over time.

Nevertheless, the kinesiology tape had a positive impact on the TTDPM in both joint positions tested (Table 3). In fact, to detect the passive movement in the knee at 30 and 60 degrees of flexion, a reduction in the amount of movement was required to perceive the joint movement in the assessment made "*immediately after taping*" and at "*24 h after taping*".

Discussion

The present study showed that there is no significant effect on the JPS immediately after and 24 h after kinesiology tape application; nevertheless, the results suggest that kinesiology tape, by increasing the ability to detect passive movement, improves proprioception in healthy young adults.

These findings are partially in agreement with other studies. Recently, Cho et al. (2015) investigated the short-term effects of Kinesio Taping® on various types of pain, active range of motion and proprioception in patients with knee osteoarthritis, and demonstrated that Kinesio Taping® applied on the quadriceps muscle improves proprioception in patients with this clinical condition (Cho et al. (2015)). However, considering the study done by Hosp et al. (2014), the enhancement of proprioception in healthy subjects is not consensual; in fact, these authors detected only improvement in proprioception at the knee joint after uphill walking in healthy women with poor proprioceptive ability (Hosp et al., 2014).

Nonetheless, our study had an interesting and unexpected result, i.e., the fact that kinesiology tape improved the TTDPM, corroborating the theory that kinesiology tape could interfere in the sensory-motor system. In fact, considering that the ability to detect passive movement involves the same proprioceptors as those involved in the

JPS, it should be logical and expected to have also found an impact on JPS due to kinesiology tape. From our point of view, these contradictory results between JPS and TTDPM should be related to methodological aspects; i.e., TTDPM seems to be more sensitive in detecting small changes in the proprioception as demonstrated by Boerboom et al. (2008).

Contrarily to what was suggested by Murray (2000), the extra stimulus through the skin and sensory stimulation due to kinesiology tape seems to be insufficient in having an impact on the JPS; this absence of influence on JPS is in accordance with other studies, namely one carried out by Halseth et al. (2004). These authors, using a similar assessment methodology, found that Kinesio Taping® when applied to the ankle and leg in apparently healthy subjects, also had no effect on the JPS immediately after its application (Halseth et al., 2004).

The direct contact of kinesiology tape with the skin leads to some hypothetical effects on proprioception due to the stimulation of cutaneous receptors, such as Meissner corpuscle end-organs, Pacinian corpuscle end-organs, hair follicle end-organs and some free nerve endings (Riemann and Lephart, 2002). From our point of view, the effect of this intervention on the mechanoreceptors localized in the muscle, capsule and ligaments does not seem to be the main explanation for the positive impact on the TTDPM; i.e. the mechanisms to explain the kinesiology tape effect on the sensory-motor system should be more related to the increase in afferent information, due to the stimulation of cutaneous mechanoreceptors, than to the interference on the main muscle and joint mechanoreceptors.

The effect on proprioception by other substantially different methods of taping techniques was also investigated by other authors. Callaghan et al. evaluated the influence of patellar taping on knee proprioception through the assessment of the JPS and TTDPM in a similar way that was used in our study, and found no influence of this intervention in either of these variables in healthy patients (Callaghan et al., 2002) and in patients with patellofemoral pain syndrome (Callaghan et al., 2008).

Apart from JPS and TTDPM, proprioception could be assessed through the ability to reproduce a target of force. Actually, the force sense could be used to determine whether the kinesiology tape improves neural activation or the mechanical properties of the muscle-tendon unity, and leads to a change in the error of the force sense (Torres et al., 2012). The improvement of force sense due to kinesiology tape was firstly detected by Chang et al. (2010). These authors found an immediate effect of applied forearm Kinesio Taping® on force sense of healthy collegiate athletes. Similarly, a significant proprioceptive deficit improvement was verified after lateral ankle sprain Kinesio Taping® application in patients with functional ankle instability (Simon et al., 2014), suggesting improvements in conscious proprioceptive awareness in both subjects with and without ankle instability.

The present research has some limitations, particularly the small sample composed of healthy subjects without proprioception deficits, limiting the generalisation of our results. Moreover, a placebo group with an intervention without "adhesive tape" to confound and blind the participants could be recommended. Although the present study did not have the aim of analysing the changes in cutaneous sense after kinesiology tape application, its results suggest that skin receptors have a role in proprioception, and yet the mechanism related to proprioception and cutaneous stimulation remains unclear. Therefore, more studies are needed to understand the effect of kinesiology tape on sensory-motor and motor control systems and they could be performed using different patterns of taping.

Conclusion

Despite kinesiology tape having no effect on JPS, the results of this study showed that it can have a positive impact on proprioception by improving the TTDPM. Hence, this technique of taping should be taken into account as a prevention strategy.

Conflict of interest statement

None declared.

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