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ORIGINAL RESEARCH

THE EFFECTS OF VARIED TENSIONS OF KINESIOLOGY TAPING ON QUADRICEPS STRENGTH AND LOWER LIMB FUNCTION

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ABSTRACT

Background: Kinesiology Taping (KT) may promote changes in muscle strength and motor performance, topics of great interest in the sports-medicine sciences. These characteristics are purported to be associated with the tension generated by the KT on the skin. However, the most suitable tension for the attainment of these strength and performance effects has not yet been confirmed.

Hypothesis/Purpose: The purpose of the present study was to analyze the effects of different tensions of KT on the isometric contraction of the quadriceps and lower limb function of healthy individuals over a period of seven days.

Study Design: Blind, randomized, clinical trial.

Methods: One hundred and thirty healthy individuals were distributed into the following five groups: control (without KT); KT0 (KT without tension); KT50; KT75 and KT100 (approximately 50%, 75% and 100% tension applied to the tape, respectively). Assessments of isometric quadriceps strength were conducted using a hand held dynamometer. Lower limb function was assessed through Single Hop Test for Distance, with five measurement periods: baseline; immediately after KT application; three days after KT; five days after KT; and 72h after KT removal (follow-up).

Results: There were no statistically significant differences ($p > 0.05$) at any of the studied periods on participants' quadriceps strength nor in the function of the lower dominant limb, based on comparisons between the control group and the experimental groups.

Conclusion: KT applied with different tensions did not produce modulations, in short or long-term, on quadriceps' strength or lower limb function of healthy individuals. Therefore, this type of KT application, when seeking these objectives, should be reconsidered.

Level of Evidence: 1b

Keywords: Kinesiology taping; athletic performance; muscle strength dynamometer; lower limb function

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INTRODUCTION

Kinesiology taping (KT) was first used in 1973 by Kenzo Kase, although its popularity increased significantly after the 2008 Beijing Olympics.[1] Currently, KT is applied in a wide range of clinical and sports-related conditions, with purported benefits including: changes of muscle function, improvements in blood and lymphatic flow, decrease in pain, provision of joint support, and an increase in skin and proprioceptive stimuli.[2,3]

The adhesive tape used in KT applications differs from other types of bandages and techniques since it does not harm the skin, it can be used for up to five days, has elastic and movement properties that are very similar to human skin, and it can be stretched to up to 140% of its original length.[3-5] There are reports in the literature showing modulations in muscle strength and motor performance after KT application, the exact characteristics sought by the athletic community and, the focus of research in both orthopedic and sports medicine fields.[4,6-8] These effects have been described as being related to the continuous tensioning of the skin by the tape, therefore activating the skins' mechanoreceptors and stimulating the central nervous system modulatory mechanisms, thereby increasing muscle excitability.[9,10]

Nevertheless, there are very few studies that have tested different tensions of KT application aiming to examine the effects of these sensory and modulatory stimuli. In addition, many of these studies, which have presented positive results, involved use, assessments and effects over shot-term applications of KT, usually with a small number of participants, analyzed using very specific evaluation methods, which may have led to results that were influenced by tests that favored familiarity in their execution. Thus, there is a lack of accurate data concerning the effects of the application of KT, particularly in relation to stimulation of the skin mechanoreceptors and muscle recruitment.[10-12]

Therefore, the purpose of the present research was to analyze the effects of different KT tensions on quadriceps femoris strength and lower limb function of healthy individuals over a period of seven days. The authors aim to providing precise data concerning the effects of the clinical application of KT.

METHODS

This study was approved by The Research Ethics Committee of *Universidade Nove de Julho* (UNINOVE) - protocol number 456.617.

Participants

Initially, 150 healthy individuals were pre-selected from institutions where the authors work. Men and women who had no complaints or pain at the lumbar spine and lower limb, who did not exercise on a regular basis, who did not have any history of allergies to their bandages and were available to participate in the proposed assessments, were pre-selected. All participants read and signed a consent form and attested their free participation in the study. The following exclusion criteria were applied: a history of surgery or fractures of the lumbar spine, neurological abnormalities, a history of previous knee pain, and lower limb muscle injuries in the 12 months prior to this study.[13] In total, 130 individuals (65 men and 65 women) aged between 20 and 40 years of age, (average $\pm$ SD: 29.20 $\pm$ 0.77 years of age; height: 1.69 $\pm$ 0.01 m; weight: 70.24 $\pm$ 0.95 kg) reached the inclusion criteria and were selected to make up the study sample.

Procedures

Following selection, all of the participants were submitted to initial clinical interview. During this assessment, the following personal data were collected: name; age; height; weight; and dominant lower limb (the preferred limb used for kicking a ball).[14] Subsequently, the assessment of the basic muscle strength and dominant lower limb function of all participants was performed. These assessments were conducted by the same examiner, who had no access to the data concerning to which group the individual was attached.

After these assessments the individuals were randomly distributed by means of a draw of sealed envelopes into the following five groups: Control Group – without KT; KT0 – application of KT without tension; KT50 – application of KT with approximately 50% tension; KT75 – application of KT with approximately 75% tension; and KT100 – application of KT with approximately 100% tension. All KT applications were performed on the quadriceps femoris of the dominant lower limb, aiming at stimulating it (see application section next). Thirteen men and 13 women (26 individuals in total) were allocated to each of the five groups. Although the individuals were aware of the presence or absence of KT, they were unaware of the tension applied. They were asked not to discuss it with the examiner or with other participants.

KT application

In the experimental groups, KT was applied in accordance with the technique described by Kase et al[4] with the objective of activating the quadriceps femoris, with initial anchoring at 10 cm below the anterior-superior iliac spine and final anchoring at the patella's base. The individuals were requested to perform a maximal extension of their knee in order to obtain length measurements and to make KT final adjustments prior to its application (Figure 1).[4-6,15-18]

In order to determine the tension imposed during the KT application, the examiner measured the distances between the application points (origin and insertion) of all individual's quadriceps. After that, the "mathematical rule of three" was used in order to determine and individualize the length of the tape. Finally, KT was applied on each individual's quadriceps according to the tension pre-established for the individual's group (Figure 2).

The same type of KT (black color) was used in all experimental groups (Kinesio Tex™ – Albuquerque, NM). All KT applications were performed by the same examiner, a licensed physical therapist with ten years of experience in the musculoskeletal practice environment, who had achieved the full international kinesiology taping credential. Prior to the application of the adhesive tape, all participants' skin was shaved

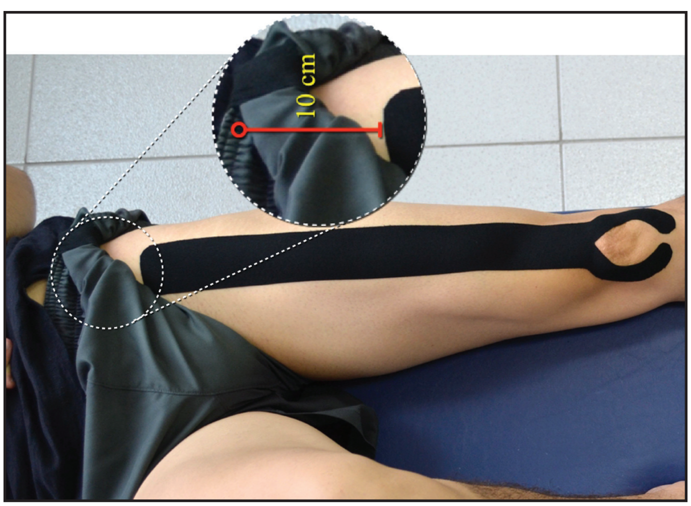

Figure 1. *Final appearance after KT application.*

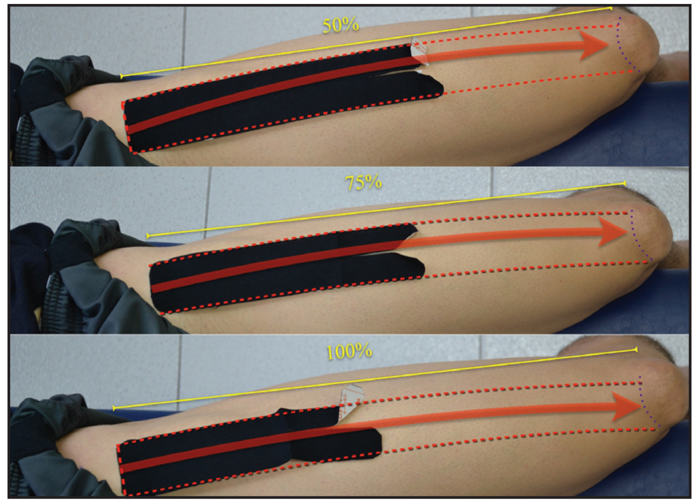

Figure 2. *KT applications with different tensions; 50%, 75% and 100% - represent approximately 50%, 75% and 100% tension applied to the tape, respectively.*

and cleaned with an antiseptic. All applications were conducted with the participant in supine position, keeping the knee flexed and beyond examination table lateral limits, with the hip in a neutral position.

Assessments

The assessments of muscle strength and dominant lower limb function of all participants were carried out, using the same order at the following time periods: Baseline – 72 hours before the application of KT; T1, T3 and T5 – immediately after the application of KT, three days later and five days later, respectively; and 72 hours after the tape had been removed (Follow-Up). The tape was removed immediately after the completion of the T5 assessment. Thus, the participants wore KT for five consecutive days.[3] The participants were instructed to continue their normal daily routines while wearing the adhesive tape. Individuals in the control group were assessed at the same time points as those in the experimental groups and received the same instructions.

Prior to beginning the present study, a pilot study was performed to assess the reproducibility and viability of assessing quadriceps strength using a hand held dynamometer. In this pilot study, five healthy individuals who did not exercise on a regular basis (10 lower limbs: five dominant and five non-dominant) were analyzed in a seven days interval. These individuals were tested using the same methods as described herein and the results obtained demonstrated an excellent reproducibility for hand held dynamometry of the quadriceps femoris, with an intraclass coefficient of correlation (ICC) of 0.96.

Quadriceps femoris strength (maximal isometric voluntary contractions) was assessed using a manual dynamometer (Lafayette Instrument Company, Lafayette, IN).[19-22] Participants were positioned on an extensor chair with their hips at 90° flexion and 0° rotation, and the knee flexed at 60°. A three-point belt was used to stabilize the torso and hips of the participants during the test. In assessments, the participants were asked to keep their arms folded in front of their torso.[19,20,22-24] The dynamometer was positioned on the anterior region of the tibia, 2.5 cm above the lateral malleolus. A nylon belt was positioned perpendicularly to the application of force in order to stabilize the dynamometer and resist the force generated by the participants' quadriceps (Figure 3).[19]

Participants received standard verbal instructions to exert maximal force during the measurements.[5] A submaximal voluntary contraction was first performed, so that they could familiarize themselves with the test, and was then followed by two measurements of maximal voluntary contraction (five seconds each), with intervals of 30 seconds between each attempt.[19,21]

After a five-minute interval, the participants' dominant lower limb function was assessed using the Single Hop

Figure 3. *Participants positioning during muscle strength assessment.*

Test for Distance. The participants were positioned in single limb support at a starting point, with their arms crossed behind the torso, and encouraged to jump as far as possible from the start point, while still able to land on the lower limb being assessed and remain stable for at least two seconds. Each individual had two attempts and the data were then analyzed. Prior to the collection of these data, all participants performed as many jumps as they felt were necessary to familiarize themselves with the test. The individuals were barefoot during the performance of the test and the distance was always measured from hallux to hallux (Figure 4).[25]

Data analysis

Muscle strength assessments were normalized by body mass using the following formula: (muscle strength [kg] / body mass [kg]) x 100.[19,20,23,24,26] The average value from the two attempts at the muscle strength assessments and the Single Hop Test for Distance were used in the analysis.

The Shapiro-Wilk test was used to confirm the normality of the data. The mean effects of the intervention and the differences in muscle strength and lower limb function – at the five assessment time points – between the groups were calculated using one-way ANOVA and the Bonferroni post-hoc adjustment. The statistical significance level was set at 5% ($p < 0.05$). The statistical analysis was conducted using version 19 of the Statistical Package for the Social Sciences (SPSS).

RESULTS

The groups in the present study were homogenous, since no statistically significant differences ($p > 0.05$) were found in terms of their demographic characteristics and the strength and function values (Table 1).

During the study, 18 individuals' did not complete the assessment protocol and their data were lost to follow up, six from the Control Group (3 men and 3 women), six from the KT0 group (5 men and 1 woman) and six from the KT50 group (5 men and 1 woman), due to their failure to appear at one of the assessments. Thus, the data for 112 individuals were used in the final analysis (Figure 5).

Table 2 presents the data obtained for the muscle strength tests and lower limb function of individuals analyzed in all study groups.

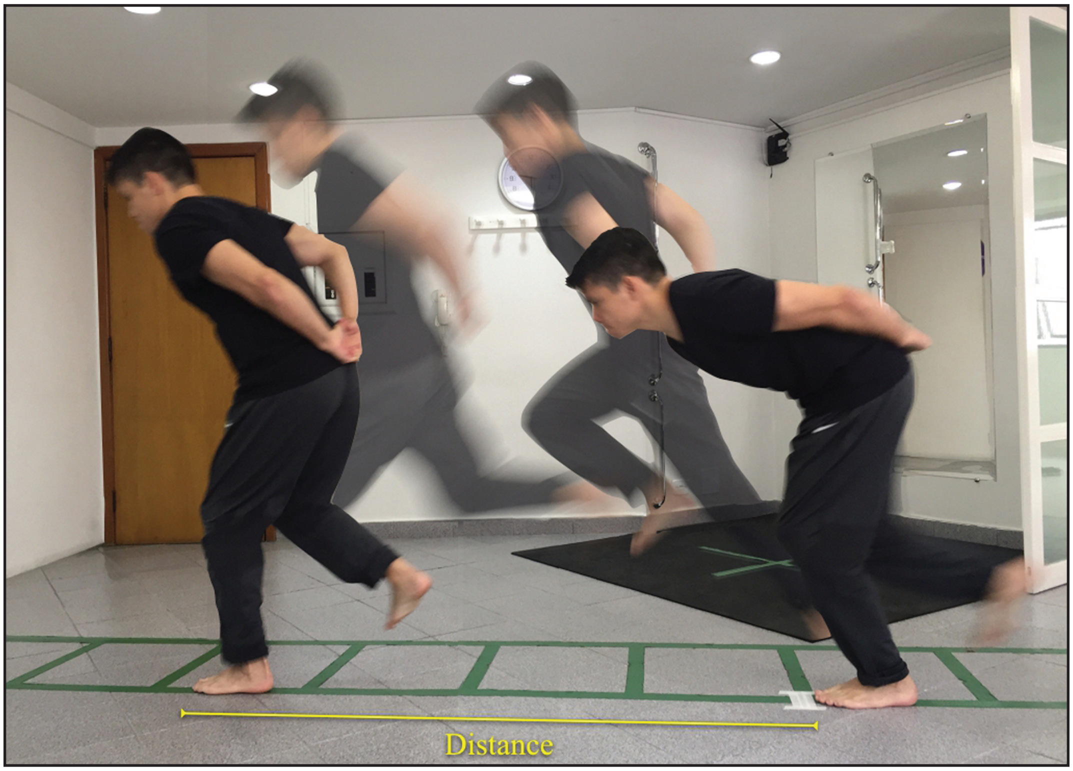

Figure 4. *Participants performing lower limb function assessment*

Table 1. *Sample demographic characteristics and descriptive data for muscle strength, and lower limb function. Reported as number (%) or mean (SD)*

	Control N=20	KT0 N=20	KT50 N=20	KT75 N=26	KT100 N=26
Gender					
Male	10 (50%)	08 (40%)	08 (40%)	13 (50%)	13 (50%)
Female	10 (50%)	12 (60%)	12 (60%)	13 (50%)	13 (50%)
Age (years)	28.3 ± 3.1	29.2 ± 1.8	28.7 ± 2.1	29.5 ± 1.4	30.3 ± 2.6
Height (m)	1.70 ± 0.10	1.68 ± 0.12	1.68 ± 0.08	1.69 ± 1.13	1.70 ± 0.06
Weight (kg)	71.5 ± 16.9	68.9 ± 15.9	66.9 ± 12.1	70.4 ± 15.7	70.5 ± 15.4
Hop Test (m)	1.37 ± 0.28	1.20 ± 0.28	1.34 ± 0.32	1.37 ± 0.28	1.27 ± 0.25
Quad Strength (kg/f)	47.8 ± 12.2	45.9 ± 13.2	48.3 ± 15.2	45.4 ± 10.5	54.4 ± 9.2

Quad Strength – quadriceps strength; m – meters; kg – kilograms; kg/f – kilograms/force; SD – standard deviation

Quadriceps strength

KT did not promote changes in the participants' quadriceps femoris strength, given that no statistically significant diferences ($p > 0.05$) were found in the comparisons between the data obtained in the control group and each of the other experimental groups (KT0, KT50, KT75 and KT100) at any of the assessment time points (Table 3).

Lower limb function

The lower limb function of the participants was also not affected by KT, as no statistically significant differences ($p > 0.05$) were observed in the comparisons between the data for Single Hop Test for Distance in the control group and in the other experimental groups (KT0, KT50, KT75 and KT100) at any of the assessment time points (Table 4).

DISCUSSION

The purpose of this blind, randomized, clinical trial was to determine the effects of different tensions of KT application on quadriceps strength and lower limb function of healthy individuals over a period of seven days. In the present study, the different

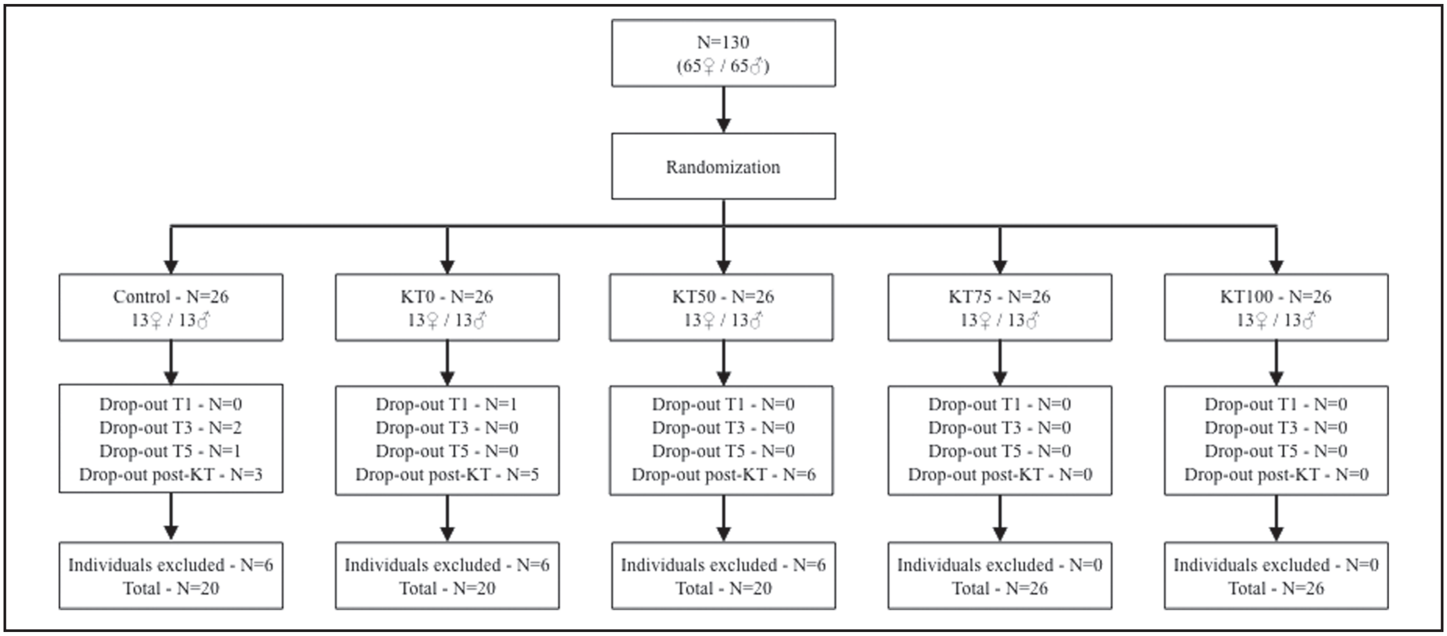

Figure 5. *Flow-chart of the participants' distribution and the final data analyzed.*

Table 2. *Muscle strength and lower limb function at all time-points analyzed, reported as means (SD)*

Outcomes	Groups	Baseline	T1	T3	T5	Follow-up
Quad Strength - Ẋ (SD)	Control	47.8 (12.2)	50.6 (13.0)	49.5 (11.3)	49.5 (12.3)	46.3 (11.1)
	KT0	45.9 (13.2)	45.4 (12.0)	47.0 (12.8)	47.3 (11.9)	46.3 (12.8)
	KT50	48.3 (15.2)	47.8 (16.6)	46.7 (15.4)	47.9 (17.3)	48.5 (12.9)
	KT75	45.5 (10.5)	45.4 (12.5)	45.1 (13.3)	49.3 (10.8)	46.9 (11.1)
	KT100	54.4 (9.2)	50.9 (9.2)	49.9 (9.0)	53.1 (9.9)	52.9 (10.3)
Hop Test - Ẋ (SD)	Control	136.8 (28.5)	137.4 (30.9)	136.1 (32.7)	136.3 (31.6)	138.6 (31.7)
	KT0	120.2 (28.6)	121.4 (26.8)	122.1 (28.7)	122.3 (26.7)	136.7 (31.9)
	KT50	134.1 (32.3)	138.7 (33.7)	137.0 (31.0)	138.5 (32.6)	141.5 (28.0)
	KT75	136.7 (28.4)	143.3 (29.0)	141.9 (31.2)	141.7 (28.9)	134.3 (25.8)
	KT100	126.6 (25.8)	131.7 (25.3)	133.4 (26.2)	135.9 (26.8)	134.3 (25.8)

Quad Strength – quadriceps strength; Hop Test – single hop test for distance; T1 - immediately after KT application; T3 - three days after KT; T5 - five days after KT; Follow-up - 72h after KT removal; □ - mean; SD – standard deviation

Table 3. *Data – mean (SD) from statistical comparisons between time points – for muscle strength*

Quad Strength	G1	G 2	Baseline			T1			T3			T5			Follow-Up		
			P	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)
G1 -G2	Control	KT_0	0.61	0.12	-9.51-5.69	0.20	-0.68	-13.08-2.81	0.52	-0.63	-10.29-5.29	0.57	-0.56	-10.03-5.60	0.99	0.59	-7.27-7.20
		KT_{50}	0.89	-0.63	-7.10-8.09	0.49	-1.36	-10.71-5.18	0.47	-0.71	-10.61-4.97	0.68	-0.40	-9.40-6.23	0.55	0.19	-5.05-9.43
		KT_{75}	0.52	1.81	-9.43-4.86	0.17	0.09	-12.64-2.31	0.23	-1.19	-11.74-2.91	0.96	-0.04	-7.52-7.17	0.85	1.91	-6.16-7.46
		KT_{100}	0.07	0.49	-0.60-13.69	0.92	-1.28	-7.10-7.85	0.90	0.12	-6.87-7.78	0.34	0.95	-3.81-10.88	0.06	-0.01	-0.23-13.39

Quad Strength – quadriceps strength; G1 – control group; G2 – experimental groups; CI – confidence interval

Table 4. *Data – mean (SD) from statistical comparisons between time points – for lower limb function*

Hop Test	G1	G 2	Baseline			T1			T3			T5			Follow-Up		
			P	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)	*P*	t	CI (95%)
G1 -G2	Control	KT_0	0.06	-1.89	-34.01-0.76	0.08	-1.74	-34.27-2.17	0.14	-1.47	-32.71-4.81	0.13	-1.50	-32.21-4.46	0.06	-1.86	-34,62-1.029
		KT_{50}	0.75	-0.31	-10.16-14.61	0.89	-0.13	-16.95-19.50	0.92	0.09	-17,86-19.66	0.80	0.24	-16.08-20.58	0.83	-0.20	-19,70-15.95
		KT_{75}	0.98	-0.01	-16.50-16.21	0.49	0.68	-11.25-23.02	0.51	0.62	-11.82-23.47	0.53	0.62	-11.80-22.68	0.73	0.34	-13,84-19.69
		KT_{100}	0.21	-1.24	-26.61-6.09	0.50	-0.66	-22.87-11.40	0.76	-0.30	-20.32-14.97	0.96	-0.04	-17.61-16.88	0.61	-0.50	-21.03-12.50

Hop Test – single hop test for distance; G1 – control group; G2 – experimental groups; CI – confidence interval

tensions of KT did not promote changes in the parameters assessed at any of the analyzed time points.

Several reports in the literature[1,3,5,13] corroborate the results of the current study, given that no changes in muscle strength or lower limb function were recorded among individuals who received KT applications, regardless of the tension of the adhesive tape.[1,5] Although KT has been described as generating tactile stimuli that alters the excitability of motor neurons and reduces the amount of time required to reach the peak torque of the muscles submitted to the application,[4,9,10] it is probable that these characteristics could not promote the expected increases in muscle strength and lower limb function in the participants of the present study, regardless of the tension used.

Conversely, Aktas *et al*[11] confirmed an increase in quadriceps strength and an improvement in lower limb function – measured with an isokinetic dynamometer and one leg hop tests, respectively – among healthy non-athletes after applying tension-free KT to the quadriceps femoris. However, unlike the present study, a "Y" shaped strip was applied to the knee (from the lateral edge of the patella to its medial region, creating a circle around it), with tension strengths ranging between 50% and 75%. This protocol sought to mechanically correct the positioning of the patella and consequently, the observed positive effects may have been directly influenced by the application of this extra strip. The stimuli promoted in the mechanoreceptors of the structures of the knee joint (skin, capsule and ligaments) may have added to the stimuli promoted by the direct application of KT on the skin above the quadriceps,[4,9,10] thereby improving the strength and function of these individuals.

A number of researchers have recommended the use of KT as a treatment resource and a method for musculoskeletal injury prevention based upon the results of their studies. [11,27-29] However, the positive results obtained in these studies[11,27-29] were achieved by means of study designs that favored the familiarization of the participants with the outcome measures, which may have had a direct effect on the muscle strength and performance results. Furthermore, unlike the present investigation, these studies assessed amateur and professional athletes who complained of pain (patellofemoral pain syndrome and shoulder impingement syndrome) immediately after the application of KT, which prevents the inference of long-term results.[11,27-29]

Pain can affect muscle recruitment and modify the biomechanics of functional and sports-related movements.[30-34] Thus, KT may have enabled altered muscle recruitment and performance of these athletes,[9] given that they required interventions that would facilitate the recruitment of motor units, reduces pain and the consequent restoration of the strength, biomechanics and function of muscles.

Several different theories have been proposed to explain how KT increases neuromuscular recruitment: the facilitation of neuromuscular stimuli,[9] the activation of skin receptors by the tactile stimulus of the tape, an increase in blood flow, and the consequent muscle activity generated by the increase in the interstitial space created by the taping procedure.[4,7] However, none of these explanations seemed to facilitate changes in the factors examined in the current research, even when greater tension of KT were applied. It is possible that the normalized neuromuscular recruitment of the healthy individuals assessed in the present study (without pain or neuromuscular deficits), as well as the absence of adhesive tape on the knee,[11] could have contributed to the lack of effect in tactile stimuli and the alteration in motor unit recruitment, thus not offering support for the participants' knees nor altering the function of their lower limbs.

Although no changes in muscle strength or lower limb function were found in the results of the present study, further studies with alternative applications of KT, as well as different populations and clinical situations, are necessary. The present study has several limitations, as it only assessed healthy individuals who did not participate in regular physical exercise. Therefore, these results cannot be extrapolated to injured populations. It well-known that athletes and people with injuries exhibit different biomechanical and muscle recruitment patterns than non-athletes and healthy people. In addition, the individuals assessed herein were not blinded in relation to their test conditions (the presence or absence of KT) and the tensions applied to the adhesive tape were not measured with a specific and validated instrument. Although the assessment methods used herein were valid and reproducible, other methods could be used to test muscle strength and lower limb function.

CONCLUSION

Different tensions of KT did not promote short nor long-term changes in isometric quadriceps strength or lower limb function of healthy individuals. Therefore, this type of KT application with for these clinical objectives needs to be reconsidered.

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