Progressive tension protocol for muscle strength with Kinesio tape in runners - double-blind randomized clinical trial

Protocolo de tensão progressiva para força muscular com Kinesio tape em corredores - ensaio clínico randomizado duplo-cego

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Date of first submission: March 18, 2022
Last received: June 20, 2022
Accepted: January 23, 2023

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Abstract

Introduction: Kinesio tape (KT), although frequently used in sports, is still a matter of debate, and the results of studies that evaluated its effects on muscle strength (MS) in athletes are still inconclusive and contradictory. **Objective:** To evaluate the effect of a progressive KT tension protocol on knee MS in runners over an eight-week intervention. **Methods:** Clinical trial involving 49 runners of both sexes randomized into two groups: KT (KT with progressive tension protocol) and placebo (KT without tension). The MS of knee flexors and extensors was evaluated by isokinetic dynamometer (60°/s and 90°/s) at four moments: (1) without KT; (2) with KT and without tension; (3) without KT (after 8 weeks after of intervention); (4) with KT and with tension (after 8 weeks after of intervention). Inter- and intra-group comparisons were made. The significance level adopted was 95% ($p < 0.05$). **Results:** There were no significant differences in MS between the groups at any of the evaluated moments. There was a statistically significant difference in MS (60°/s) in both groups (KT and placebo) when comparing moments 4 and 2 for knee flexors, and in the placebo group between moments 4 and 2 and moments 4 and 3 for knee extensors. **Conclusion:** The progressive tension protocol of KT was not able to intervene in the SM gain of knee flexors and extensors of runners in inter and intragroup comparisons.

Keywords: Athletes. Clinical trial. Muscle strength. Torque.

Resumo

Introdução: *A* Kinesio tape *(KT), apesar de muito utilizada na prática esportiva, ainda é motivo de debate e os resultados de estudos que avaliaram seus efeitos na força muscular (FM) em atletas ainda são inconclusivos e contraditórios.* ***Objetivo:*** *Avaliar o efeito de um protocolo de tensão progressiva KT na FM do joelho em corredores ao longo de uma intervenção de oito semanas.* ***Métodos:*** *Ensaio clínico envolvendo 49 corredores de ambos os sexos randomizados em dois grupos: KT (KT com protocolo de tensão progressiva) e placebo (KT sem tensão). A FM dos flexores e extensores do joelho foi avaliada por dinamômetro isocinético (60°/s e 90°/s) em quatro momentos: (1) sem KT; (2) com KT e sem tensão; (3) sem KT (após 8 semanas); (4) com KT e com tensão (pós-protocolo 8 semanas). Comparações inter e intragrupos foram feitas. O nível de significância adotado foi de 95% (p < 0,05).* ***Resultados:*** *Não houve diferenças signi-ficativas na FM entre os grupos em nenhum dos momentos avaliados. Houve diferença estatisticamente significante na FM (60°/s) em ambos os grupos (KT e placebo, quando comparados os momentos 4 e 2 para flexores de joelho, e no grupo placebo entre os momentos 4 e 2 e os momentos 4 e 3 para extensores de joelho.* ***Conclusão:*** *O protocolo de tensão progressiva de KT não foi capaz de intervir no ganho de FM de flexores e extensores de joelho de corredores em comparações inter e intragrupos.*

Palavras-chave: *Atletas. Ensaio clínico. Força muscular. Torque.*

Introduction

Invented by Japanese chiropractor Kenzo Kase in the 1970s, Kinesio Tape (KT) or Elastic Bandage (EB) had its first worldwide appearance during the Seoul Olympic Games in 1988 and became popular after the 2008 Olympic Games in Beijing, where US beach volleyball gold medalist Kerri Walsh appeared wearing the tapes after a rotator cuff injury to her right shoulder.[1,2] Clinical trials using KT have been published frequently, and among the various conditions investigated are studies that aim to assess the effects of KT on muscle strength in different populations and conditions.[1,2]

KT consists of a colored, adhesive tape (no latex), 100% cotton, with elasticity.[1-3] It can be applied directly to the skin and tensioned longitudinally to up to 140% of its original length (varying by brand). It can last for three to five days on the skin, and can even be used in water.[1,3] The therapist decides which location, technique and tension level will be used on each patient according to their specific conditions.[1,3] The combination of the elasticity of KT and its application to elongated muscles creates convolutions (waves formed in the skin after the application of KT in stretching tension) in the upon return to the neutral position and it is believed that these convolutions reduce pressure on the mechanoreceptors located below the dermis, thus reducing nociceptive stimuli and, consequently, pain.[3] Convolutions are also believed to alter muscle recruitment through inhibitory and excitatory (facilitatory) neuromuscular mechanisms, depending on the direction of tape application.[3]

When KT is applied at the muscle insertion and extended with adequate tension to its origin, it is proposed that the regression effect can inhibit motor neurons by stretching Golgi tendon organs at the distal end of the muscle.[1,2,4,5] When applied in the opposite way, from the origin to the insertion of the muscle, it is believed that it can increase the contraction of the muscle spindle reflex and facilitate the contraction of the muscle, which would therefore result in an increase in muscle activity and consequently in muscle activity.[1,2,4,5]

There is also the hypothesis that the cutaneous stimulation provided by the tape, involving type II mechanoreceptors located in the depth of the dermis, may induce greater recruitment of motor units and facilitate muscle strength gain.[1,2,4,5] Although the physiological principles underlying such gains have never been convincingly elucidated, this concept is based on early neurological studies demonstrating that afferent skin signals presumably associated with these proprioceptors modify the excitability of motor units and modulates proprioceptive activity, leading to favorable conditions for muscle strength gain.[1,2,4,5]

KT is one of the most commonly used elastic tapes in sports in terms of prevention, treatment and improvement of athletic performance.[6-8] Although often applied in athletes, its effectiveness is still a matter of debate, and the results of studies that evaluated its effects on muscle strength are still contradictory and inconclusive.[6-8] There is limited and contradictory evidence supporting whether KT facilitates increased muscle strength in athletes[6,9,10] or not.[11-16] These findings can be explained by the variable methodological quality and small samples, usually of convenience, of the primary studies, which limits the strength of the results of current research on the subject.

In view of the contradictory results reported in the literature and the emergence of new studies in recent years, in an attempt to resolve the doubts that still exist in the literature about the application of KT in relation to muscle strength, the objective of this clinical trial was to evaluate the effect of a progressive tension KT protocol on knee muscle strength in runners over eight weeks of training and intervention.

Methods

Study design

This is a randomized controlled clinical trial that included 52 runners who met the eligibility criteria: aged between 18 and 60 years; to be physically able to participate in the experimental study; to be completely independent in performing basic activities of daily living; not present physical, hearing or visual impairment that prevents the performance of the exams or the use of prostheses or orthopedic orthotics; no history of knee, ankle, or hip injuries; no allergies to elastic bandages; having time to participate in interventions; no cognitive deficit according to the Mini Mental State Examination (MMSE); having training frequency of at least two times a week for more than three months.

All those included in the study participate in a running group in the city of Jacarezinho, Paraná, Brazil, and were training with the aim of improving their performance/results; actively participate in sports competitions and have sports training and competition as a focus of personal interest, to which they dedicate several hours of the day or most days to these activities, exceeding the time allocated to other types of leisure activities; although most are not formally registered with a local, regional or national sports federation, they regularly participate in local competitions. Participants who were unable to complete the assessments and/or interventions for any reason and those who, for some reason, decided to withdraw their consent to the research were excluded.

The sample size was calculated using the Bioestat 5.3 program (Instituto Mamirauá, Amazonas, Brazil), taking into account the values of isokinetic muscle strength (Nm) of knee extensors at an angular velocity of 60°/s, available in a previous study.[11] In this study, Gloria et al.[11] divided their participants (30 professional male soccer players) into two groups (15 participants each): KT group (Kinesio Tex Gold, black color) applied with the muscle activation technique, in the form "Y-strip" (from origin to muscle insertion) on the rectus femoris muscle of the dominant leg, with 15-20% tension on the tape; placebo group (Kinesio Tex Gold, black color) applied transversally, without tension, on the rectus femoris muscle in the middle third of the thigh. In this case, the post-intervention mean and standard deviation were used between the KT group (262.16 ± 17.88) and the placebo group (239.05 ± 37.73), with test power at 80% and alpha value at 0.05, which generated the need for at least 26 participants in each group.[11]

This clinical trial followed the Consolidated Standards of Reporting Trials statement.[17] Once the participants accepted the invitation to participate in the study and clarified all doubts about the study, they gave their written consent and were. Of the 52 runners assessed for eligibility, three were excluded (one moved out of town; one presented ankle fracture during activity of daily living; and one was diagnosed with thyroid tumor) and chose to withdraw their consent to participate in the study. Therefore the final sample consisted of 49 participants (Figure 1).

After the initial assessment, participants were randomly divided, following simple computerized randomization procedures, into two groups: KT (KT with progressive tension protocol) and placebo (KT without tension). The allocation sequence was generated by a researcher who was not involved in the assessment and interventions, and a research assistant assigned participants to the interventions. The evaluators were blinded, since the isokinetic evaluation of muscle strength was performed by a professional trained only for this evaluation and all participants received the application of an elastic bandage. Participants were also blinded as to which group they belonged to, as both groups received the application of KT, differing only in terms of whether the tape was tensioned or not. The statistician was also blinded to the intervention.

All participants agreed to voluntarily participate in the research, signing the free and informed consent form after being informed about the study. The study was carried out in accordance with the Declaration of Helsinki and submitted to the Ethics and Research Committee Involving Human Beings under No. 3,059,113 of the Universidade do Norte do Paraná (UNOPAR), and is registered at ClinicalTrials.gov under No. NCT04888520.

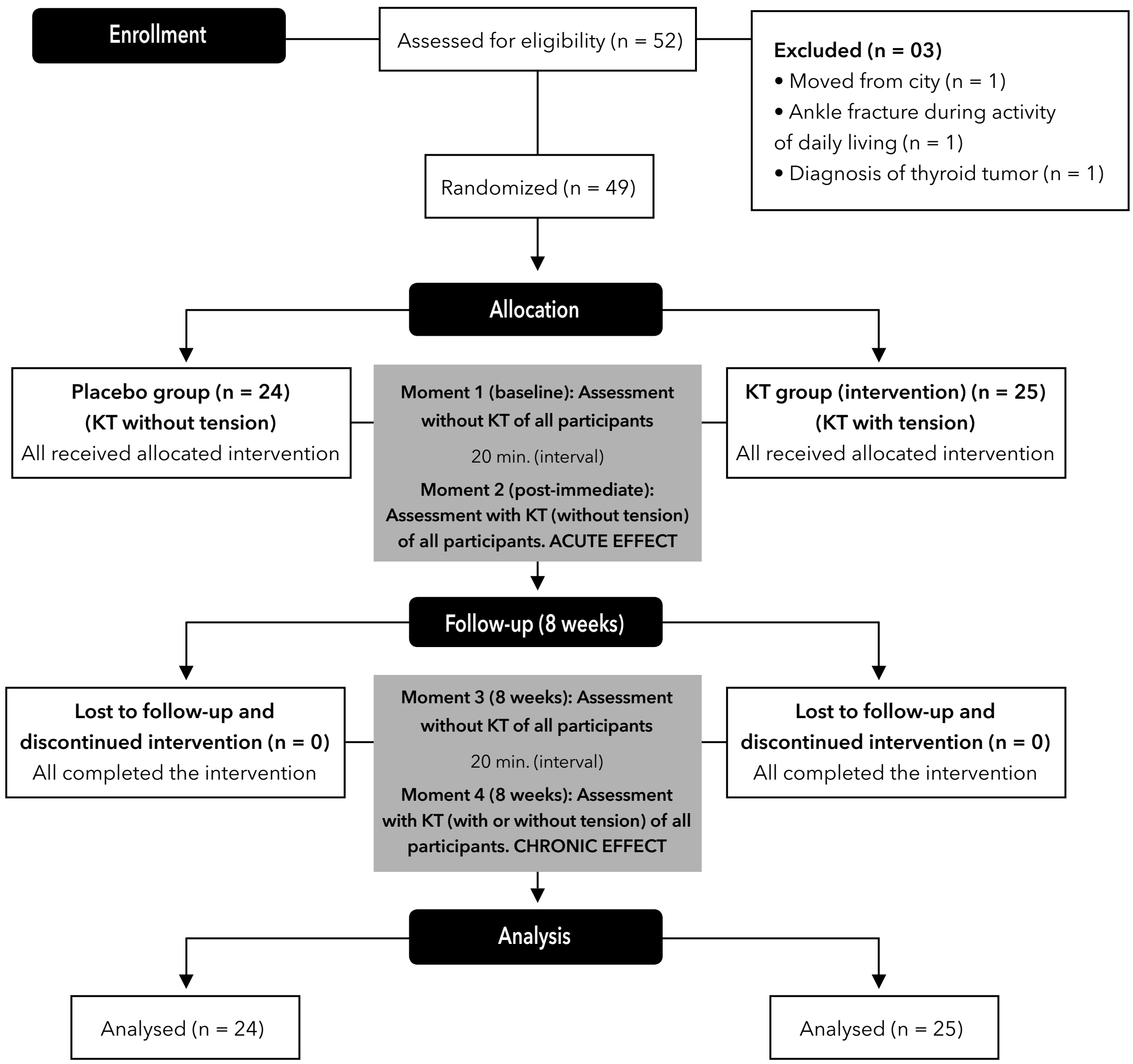

Figure 1 - Flow diagram of the study (KT = Kinesio tape).

Procedure

A professional with practice, trained and certified in the application of KT, led the interventions and was responsible for the application of KT in both groups. This non-blind professional was not involved in the evaluation procedures and accompanied each participant in the weekly training meetings - three times a week - for the applications or removal of the tape and to verify the frequency of the participants in the running training and their involvement in the study. All KT applications were performed on the Monday prior to running training, and KT was withdrawn on Friday, after the last training day of the week; while on Wednesday there was only training monitoring. Daily monitoring by social media, such as Whatsapp, was also carried out in case of doubts and to provide guidance on the KT. The intervention lasted eight weeks, with KT application once a week (Mondays), and remained on the participant's skin for five days (until Friday). If the KT loosens itself from the skin (completely or partially) before this period, the event should be immediately reported to the responsible researcher via Whatsapp with photos so that the participant could receive adequate guidance on what to do. On weekends (Saturday and Sunday), the participant remained without KT so that the skin could rest.

An initial assessment (baseline) was carried out without any intervention (application of KT), and afterwards both groups received the first intervention with the tape without tension. Twenty minutes after applying the tape without tension in both groups, an immediate reassessment of the isokinetic muscle strength of all participants was performed in order to verify the acute effect of KT without tension. In this case, the participant left the laboratory with the tape (first week of intervention) ready for training, whose application was the same (without tension) for both groups in the first week, and returned only for reassessment after eight weeks. The placebo group remained tension-free throughout the study and the progressive tension protocol began in the second week for the KT group (intervention group), since the first week of application must be performed without tension so that the patient adapts to KT (Figure 1).

Running workouts

The running training lasted approximately 60 minutes, three times a week on alternate days (Monday, Wednesday and Friday), and included: interval training (sprints of 800, 1000, 400 and 500 m, interspersed with walks), strength/resistance training (with a protocol with educational exercises for running), and continuous or volume training (distances between 5 and 12 km) with each day of the week being a specific training, using as training load the percentage that was achieved by the participants in the Léger test[18] or in the 20-meter running test, a field test to check the cardiorespiratory fitness of participants.

The running workouts included initial stretches lasting 5 to 10 minutes for the main muscle groups worked (such as quadriceps, hamstrings, hip, shoulder and trunk adductors and abductors), 5-minute warm-ups (global mobility exercises and sprints - short and light), total running times of 40 to 45 minutes, and final 5-minute stretches of the main muscle groups worked (such as quadriceps, hamstrings, hip adductors and abductors).

Continuous training intensities (subjectively controlled by the Borg scale) were 80%, progressing to 100% of maximum speed, with distances between 5 and 12 km. In the interval training, they ranged from 100 to 115% in the 800 m and 1000 m distances, while in the 400 m and 500 m training the intensities were 105%, progressing to 120%, with stimuli from 4 to 10 shots per training and with walking rest. Strength/endurance training consisted of specific educational exercises for running, for the development of strength and power, where it was possible to identify faulty movements, and thus develop strategies to improve them, and consequently improve the economy and performance of the race. This training used body weight as resistance, alternating the strengthening of upper and lower limbs and trunk - 5-8 exercises were performed, of 4-5 series, lasting 20 seconds each series, seeking the maximum number of repetitions in this interval of duration time, with a rest of 60 to 90 seconds.

Initial and final assessment

The muscle strength of the right knee extensors and flexors was evaluated using a Biodex Multi-Joint Pro isokinetic dynamometer at an angular velocity of 60° and 90° per second, respectively. Five repetitions were performed for each angulation analyzed (60°/s and 90°/s), with a 30-second rest interval between them, and the highest peak torque of the five repetitions collected was considered for analysis.[5,6,11] The assessment was performed in concentric/concentric mode and the knee ranged from 0° to 90° to test the flexors, and from 90° to 0° to test the right knee extensors.[5,6,11]

Before testing the dynamometer, the device was properly calibrated and ready to store participant data. The assessment was performed with the participant sitting and stabilized in the chair with hip flexion of 85°, with a strap positioned horizontally in the pelvic region and two straps crossed in front of the trunk, in the thoracic region, while another strap stabilized the thigh of the lower limb contralateral to the assessed limb.[5,11]The equipment rotation axis was aligned parallel to the axis of the evaluated knee joint (lateral epicondyle), and the lower limb was fixed to the lever arm of the dynamometer, with the support pad two centimeters from the heel.[5,11]

The participant had a brief familiarization with the equipment in relation to strength and range of motion after being properly instructed by the evaluator on the proper execution of the test. They were verbally encouraged and given visual feedback on the monitor screen about the test. The same protocol was repeated after 30 seconds of recovery for the second test speed.[11]

The evaluations were carried out in four moments: two initial evaluations, to verify the acute effect of the elastic bandage without tension (moment 1: without KT; moment 2: with KT, but without voltage applied to the KT); two final evaluations, to verify the chronic effect of eight weeks and consequently eight KT applications (moment 3: without KT; moment 4: with KT, with or without tension according to randomization).

Intervention

KT was applied only to the rectus femoris muscle of the dominant lower limb. The skin was free of moisturizing lotions or oils, hairless and cleansed with alcohol and cotton wool prior to KT application. When removing the protective paper from the KT adhesive, the tape was immediately applied to the skin of the participant and no contact between the evaluator with this area was made so that there was no decrease in the adhesion capacity of the tape, thus the adhesive protection was not completely removed from the tape before application.

Regarding the application of KT, the base of the tape was applied 5 cm below the origin of the rectus femoris (inferior anterior iliac spine) - without tension in this part of the tape (2 to 3 cm at the beginning) -, going towards its insertion (base of the patella, through the suprapatellar ligament) with or without tension according to the group to which the participant was assigned (Figure 2).

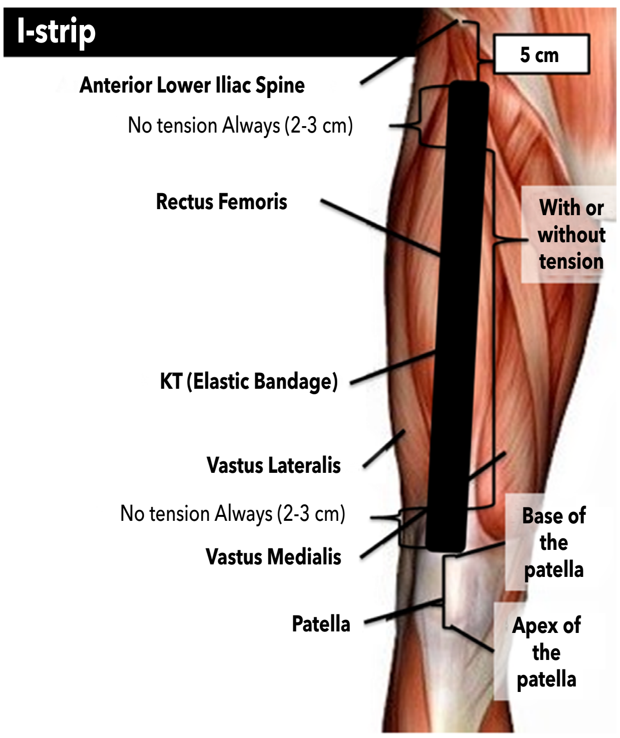

Figure 2 - Kinesio tape over the rectus femoris muscle.

The last 1 or 2 cm of tape was also applied without tension to avoid discomfort, regardless of the group to which they belonged. The tape was applied in "I" ("I-strip"), with the participants in the supine position on the stretcher, with the hip flexed at 30° and the knee flexed at 60° (these angles were measured using a goniometer). KT was applied without tension in the first week of intervention for both groups and tension increased once a week throughout the seven weeks only for the KT group (intervention group), while the placebo group remained tension-free throughout the intervention (Figure 2).

All participants were randomly divided into two groups:

• Placebo group - no tension in any of their tape applications; that way, the size of the tape over the applied area was always the same;

• KT group (intervention group) - progressive tension over the weeks; this protocol is based on reducing the length of the tape over the weeks, in relation to the size of the applied area (which will always be the same), which generates a longitudinal tension in the tape in relation to the participant's skin (protocol described below, in Figure 3).

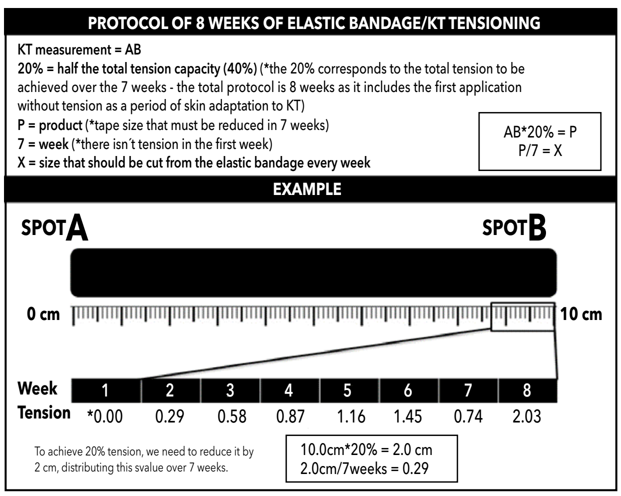

Figure 3 - Progressive tensioning protocol for Kinesio tape (KT group - intervention).

The Therapy Tex® brand has an elastic deformation capacity of up to 40%. The KT progressive tension protocol worked at 20% of the KT's elastic deformation capacity. Voltage was given from point A to point B in order to generate excitatory stimuli.[1,2,4]

The percentage of 20% reduction in tension was distributed over the seven weeks of intervention, with the first week of the protocol including the application without tension. Tape reduction was controlled by the formula: (size of skin application area cm *20%/7 weeks = tape size to be cut in each of seven applications from the second week. Tape size and tape application area were calculated in centimeters (protocol described below in Figure 3).

Statistical analysis

Descriptive data were expressed as mean and standard deviation or median and interquartile range. Data normality was verified by the Shapiro-Wilk test. The homogeneity of variances was determined by Levene's test. To verify whether the two groups showed pre-intervention differences, Student's t test for independent samples or the Mann-Whitney U test was used. Pearson's χ^2 test was used for gender comparison. For comparison between groups, analysis of variance (ANOVA) was used mixed with two factors and repeated measures, with post hoc Bonferroni test. Effect sizes were calculated using Cohen's d, which were considered small (0.20), medium (0.50) or large (0.80). Intent-to-treat analysis was used, including all randomized participants (missing post-intervention data were imputed to baseline data). For all tests, the significance level was 95% ($p < 0.05$). Analyzes were processed in the SPSS 20.0 program (Chicago, IL, USA), except for effect size calculations (Cohen's d), which were processed in the G Power 3.1 program (Franz Faul, Universita Ä Kiel, Germany).

Results

The characterization of the sample is shown in Table 1 and, as stated, there were no statistical differences between the groups ($p \geq 0.05$) for any of the variables analyzed.

Table 1 - Baseline characteristics of participants

Characteristics	All (n = 49)	KT group (n = 25)	Placebo group (n = 24)	p-value*
Age (years), mean (SD)	38.8 (9.7)	39.4 (10.2)	38.2 (9.2)	0.660
Sex (female), n (%)‡	33 (67.3)	16 (64.0)	17 (70.8)	0.610
Weight (kg), mean (SD)	72.2 (11.2)	75.0 (10.2)	69.3 (11.6)	0.074
Height (cm), mean (SD)	164.6 (9.6)	166.4 (10.1)	162.6 (8.9)	0.167
BMI (kg/m^2), mean (SD)	26.6 (3.3)	27.1 (3.2)	26.1 (3.4)	0.300
Running practice time (months), median (IQR)†	6 (4-12)	8 (5-12)	6 (3-12)	0.593
Weekly running practice frequency (days), median (IQR)†	3 (2-3)	3 (2-3)	3 (3-3)	0.240
Isokinetic muscular strength (Nm), mean (SD)				
Knee extensors 60°/s	167.2 (50.8)	177.4 (52.6)	156.6 (47.6)	0.154
Knee flexors 60°/s	83.7 (28.7)	84.3 (25.7)	83.1 (32.1)	0.889
Knee extensors 90°/s	147.4 (47.0)	157.5 (48.5)	136.8 (43.9)	0.125
Knee flexors 90°/s	78.5 (27.5)	79.3 (24.6)	77.7 (30.8)	0.832

Note: KT = Kinesio tape; SD = standard deviation; IQR = interquartile range (25th-75th percentiles); BMI = body mass index. *Student t test for independent samples. ‡Pearson's chi-square. †Mann–Whitney U test.

The intra- and inter-group comparisons in the four evaluation moments are shown in Table 2. There were no significant inter-group differences (between the KT group and placebo group - in all comparisons: $p \geq 0.05$) in both angular speeds (60°/s and 90°/s), both for knee flexors and extensors. There was no significant difference in intragroup comparisons for 90°/s angular velocity, in both groups (KT and placebo), between any of the evaluated moments, both for knee extensors and flexors.

In the intragroup comparison (pre- and post-intervention), for the angular velocity of 60°/s, there was a significant improvement for the KT group when the moment 4 (8 weeks with KT) and the moment 2 (post-immediate with KT) were compared for knee flexors. The same occurred in the placebo group. Still in the intragroup comparison, in the placebo group, there was a significant difference when comparing moments 4 (8 weeks with KT) and moment 2 (post-immediate with KT) for knee flexors and extensors. In this same group (placebo group), in the intragroup comparison between moment 4 (8 weeks with KT) and moment 3 (8 weeks with KT), there was a significant difference for knee flexors at the same angular velocity (60°/s).

Table 2 - Intra-group and between-group comparisons for isokinetic muscular strength (in Nm)

Characteristics	KT group (n = 25)	Placebo group (n = 24)	Effect size	p-value
Knee extensors 60°/s				
Moment 1: Baseline (without KT)	177.4 (52.6)	156.6 (47.6)	0.998	0.377
Moment 2: Post-immediate (with KT)	180.1 (57.2)	155.4 (46.6)		
Moment 3: 8 weeks (without KT)	182.5 (54.8)	157.5 (44.5)		
Moment 4: 8 weeks (with KT)	183.1 (57.2)	163.2 (48.4)[a,b]		
Knee flexors 60°/s				
Moment 1: Baseline (without KT)	84.3 (25.7)	83.1 (32.1)	0.403	0.659
Moment 2: Post-immediate (with KT)	85.8 (27.6)	83.6 (30.0)		
Moment 3: 8 weeks (without KT)	87.6 (26.0)	88.3 (30.5)		
Moment 4: 8 weeks (with KT)	89.2 (28.7)[a]	88.7 (28.6)[a]		
Knee extensors 90°/s				
Moment 1: Baseline (without KT)	157.5 (48.5)	136.8 (43.9)	0.337	0.742
Moment 2: Post-immediate (with KT)	158.5 (51.2)	139.0 (42.3)		
Moment 3: 8 weeks (without KT)	159.4 (48.6)	139.2 (40.0)		
Moment 4: 8 weeks (with KT)	161.5 (49.2)	144.0 (42.0)		
Knee flexors 90°/s				
Moment 1: Baseline (without KT)	79.3 (24.6)	77.7 (30.8)	1.560	0.219
Moment 2: Post-immediate (with KT)	79.7 (25.0)	78.1 (27.8)		
Moment 3: 8 weeks (without KT)	81.5 (25.7)	81.8 (29.2)		
Moment 4: 8 weeks (with KT)	88.1 (38.2)	80.1 (26.0)		

Note: Outcome values at each time point are mean (standard deviation). Comparisons by ANOVA mixed with two factors and repeated measures, with post hoc Bonferroni test: [a]Significantly different from moment 2 ($p < 0.05$); [b]Significantly different from moment 3 ($p < 0.05$). KT = Kinesio tape. Effect size: Cohen's d.

Discussion

The aim of this study was to evaluate the effect of a progressive KT tension protocol on knee muscle strength (flexors and extensors) in runners. Therefore, a protocol of progressive tension (progressive increase of 0-20% tension) of KT was carried out over an eight-week intervention, with a weekly application. The main results of this intervention were: (1) there were no statistically significant differences in muscle strength between the groups at any of the angular velocities (60 and 90°/s), both for knee flexors and extensors; (2) there was no statistically significant difference in muscle strength for the 90°/s angular velocity, in both groups in intragroup comparisons (pre- and post-intervention), between any of the evaluated moments, both for extensors and for

for knee flexors; (3) there was a statistically significant difference in muscle strength for 60°/s angular velocity in both groups, in the intragroup comparison between moments 4 and 2 for knee flexors and in the placebo group between moments 4 and 2 and moments 4 and 3, for knee extensors.

Koç et al.[13] investigated whether the elastic bandage/KT applied to the quadriceps muscle affects isokinetic knee muscle strength in volleyball players in an eight-week period and, like this study, did not find statistically significant differences when comparing the KT group and the control group (without tape) in relation to quadriceps peak torque ($p > 0.05$) (intergroup), not even when comparing the three evaluated moments (time 1: before KT application; time 2: 45 minutes after KT application; moment 3: after 8 weeks of KT application - intragroup). The study by Koç et al.[13] applied KT on the rectus femoris and biceps femoris muscle using muscle facilitation techniques, that is, from origin to muscle insertion, but in a "Y-strip", differing from the present study that applied the tape just over the rectus femoris muscle in "I-strip"; it differs also in relation to the fact that the tension applied to the tape was controlled in this study progressively up to 20% of the maximum tension (progressive tension protocol), while Koç et al.[13] used 10-15% of tension, controlled subjectively, and did not mention the frequency of weekly application of KT. We can also highlight the greater number of participants involved in the current study (49 participants of both sexes) compared to Koç et al.[13] (20 women), and the different sport modality (runners and volleyball players), although both have used an angular velocity of 60°/s.

Other studies such as those by Glória et al.,[11] Serra et al.,[14] Limmer et al.,[19] Chang et al.,[20] Zhang et al.,[21] and Chang et al.[22] also corroborate our findings. They concluded that KT does not influence muscle strength gain.[11,14,19-22] All the cited studies included trained participants (athletes) and assessed muscle strength using validated instruments after intervention with KT, but the intervention time included only one application of the tape in different muscle groups, except Glória et al.[11] and Serra et al.[14] who applied the tape to the rectus femoris muscle, as in this study.

Choi and Lee[5] in their study whose objective was to determine the effects of the direction of application of the kinesiological tape on the strength of the fatigued quadriceps muscles that included 15 athletes, concluded that the application of the KT can improve the strength of the muscles fatigued quadriceps, regardless of the application direction ($p = 0.001$). This difference is probably due to the fact that the intervention time is different - this study included eight weeks of intervention, and Choi and Lee[5] performed the immediate reassessment after the application of the tape -, and the assessment condition was also different, since Choi and Lee[5] included fatigued participants.

Other studies such as those by Ataullah et al.,[23] Fereydounnia et al.,[24] and Tanoori et al.[25] evaluated the acute effect of KT on muscle strength and obtained positive results (KT may favor muscle strength gain) that can be easily justified by the differences between these studies. Although they all include trained participants (athletes) and assess muscle strength using validated instruments after KT intervention, the intervention is limited to just one application of the tape on different muscle groups (gluteus medius, peroneus longus and gluteus medius, pectoralis major and infraspinatus, respectively) and concern the acute effect of the intervention, differing from this study.

Regarding the ways of applying KT, among the studies cited that concluded that there is no influence of KT on muscle strength gain, only Glória et al.[11] and Koç et al.[13] applied KT in a way that is believed to be favorable to muscle strength gain (from origin to muscle insertion), while the others did not cite or apply KT in the opposite way.[14,19-22] Likewise, among the cited articles that concluded that there is an influence of KT on muscle strength gain, only Choi and Lee,[5] Ataullah et al.,[23] and Fereydounnia et al.[24] applied KT, of origin for muscle insertion; while only Tanoori et al.[25] applied KT in the opposite way. In this way, we can see that this study and the others cited (disregarding their differences) question the findings of Choi and Lee,[5] who concluded that the form of KT application (from origin to insertion and from insertion to muscle origin) can directly influence muscle strength gain.

Among the articles that were analyzed for the construction of this discussion, none detailed the criteria used to define their participants as athletes, and Limmer et al.[19] was the one that gave more details about its participants and even so does not include all the criteria proposed by Araújo and Scharhag.[26] Thus, if we consider the definition by Araújo and Scharhag,[26] no article could be effectively compared with each other and the absence of this information in the evaluated articles can be considered a limitation of current studies.

Currently, few systematic reviews with and without meta-analysis have been published involving muscle strength outcomes and KT, and none of them exclusively included athletes.[1,2,27] Regardless of the population, there is still no consensus on the influence of KT on muscle strength, however, the methodological quality of the studies currently found in the literature on the subject is still questionable and except for Koç et al.,[13] all others found only assess the acute effect of KT and include only one application of the tape.[1-3,6,27]

We can consider as limitations of this study the number of participants, the angular velocities used, and the intervention time. We observed that the 90°/s angular velocity did not obtain any positive result in relation to strength gain, and that the 60°/s velocity showed positive results. These favorable results for muscle strength gain can be attributed to the effect of time and training, as both flexors (which did not receive intervention) and knee extensors (which received intervention) showed positive results in relation to strength gain. If an angular velocity of 30°/s were used in the evaluations and both lower limbs (those that did not receive any intervention) were evaluated, we would certainly have different results and perhaps favorable to muscle strength gain.

Based on conflicting results and methodological limitations in the current literature, additional studies using more rigorous methodology may lead to further clarification on the influence of KT on muscle strength and come to fill in the gaps left by the limitations of this study. However, to date, we know that KT has not been able to significantly alter runners' muscle strength and we cannot extrapolate these findings to athletes in other sports or in conditions other than healthy individuals. The application of KT is considered safe and presents few adverse events, and when applied correctly, it can still act as a complementary therapy and this study is not intended to discourage its use, only to demonstrate that it alone is not capable of directly intervening in strength gain muscle.

Conclusion

The progressive tension protocol of KT did not present significant effects in relation to the gain in muscle strength of knee flexors and extensors of runners when compared with a placebo group. Although, for an angular velocity of 60°/s, in both groups (KT and placebo) there was a statistically significant difference in the comparison between moments 4 and 2 for knee flexors; and in the placebo group, between moments 4 and 2 and moments 4 and 3, for knee extensors. These effects can be attributed to the effect of time and training and not the presence of KT. Future studies involving different populations, in order to verify the chronic effect of KT application, are still necessary.

Acknowledgements

We are grateful to all the authors of the original works cited in this study, who promptly helped us by sharing their manuscripts or providin gadditional data necessary for this randomized controlled clinical trial. We thank the CAPES foundation for providing us with the means to carry out this manuscript. We would also like to thank the organizers and participants of the Papa-Léguas running group, as without them this study would not have been possible.

Authors´ contributions

MRS and RACA elaborated and approved the study design. MRS, ACFTDA, TTDA and FJJ collected the data and, along with RACA, analyzed and interpreted it. RGO was responsible for the statistical analysis. MRS and RACA elaborated and reviewed the manuscript, and all authors approved the final version.

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