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Effect of Kinesio Taping on gastrocnemius activity and ankle range of movement during gait in healthy adults: A randomized controlled trial

Q5 J. Martínez-Gramage [a,*], M.A. Merino-Ramirez [b], J.J. Amer-Cuenca [a], J.F. Lisón [a]

[a] *Department of Physiotherapy, Motion Analysis Laboratory LAMCEU, Faculty of Health Sciences, Universidad CEU Cardenal Herrera, Moncada, Valencia, Spain*

[b] *Department of Clinical Neurophysiology, Hospital de La Ribera (Alzira-Valencia), Associate Professor at Universidad CEU Cardenal Herrera, Moncada, Valencia, Spain*

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ABSTRACT

Objective: to examine the effect of KT on gastrocnemius surface electromyography (SEMG) activity and ankle range of motion during walking in healthy subjects.
Design: Randomized controlled trial, with concealed allocation and assessor blinding.
Setting: University Biomechanics Laboratory.
Participants: Thirty six healthy physiotherapy students were randomized to KT or control group.
Outcome Measures: At baseline and immediately after 72 h with the tape in situ: amplitude of LG SEMG activity during the stance phase, duration of the LG activity, onset and offset times of LG activity, ankle plantar- and dorsiflexion peaks, and the cadence of gait.
Results: ANOVA revealed a significant time × intervention interaction effect across two variables: duration of LG activation, $F(1, 33) = 4.71$, $p = .037$, $\eta = .015$; and onset $F(1, 33) = 7.92$, $p = .008$, $\eta = .037$. KT group showed significantly shorter duration of the LG activity as compared with control, and similar results were observed when comparing the onset of LG activation. No statistically significant differences between both groups were noted in the rest of the outcomes.
Conclusion: KT does significantly shorten the duration of the LG activity during gait when applied 72 h in healthy adults. However, this result was not accompanied by a significant reduction in the amplitude of LG SEMG activity.

1. Introduction

Kinesio Taping (KT) is a technique utilizing an elastic tape originally created by Kenzo Kase in the 1970s. Having increased in popularity since the Beijing 2008 Olympics (Williams, Whatman, Hume, & Sheerin, 2011), KT is a relatively new method that is being widely used as a therapeutic (rehabilitation protocols and prevention of sports injuries) and performance (athletic field) enhancement tool.

KT is a cotton, latex-free, adhesive, elastic tape that can be applied theoretically to any muscle or joint of the body. It is unique compared with other standard rigid types of tape because its elasticity allows for elongation 130%–140% of its original length -producing less mechanical restriction to movement-, and mimic the thickness and flexibility of the skin. It can be worn up to 3–5 days without interfering with the daily hygiene and without compromising its adhesive properties (Kase & Wallis, 2002).

According to the manufactures, the controllable variables in KT application include the degree of prestretch applied to the tape, the position of the area to be taped, and the treatment goals. Kase, Hashimoto, and Tomoki (1996) proposed several taping mechanisms with various intended outcomes depending on the application technique.

Two of the proposed potential benefits of KT include: (1) correcting misaligned joints by relieving muscle spasm (inhibiting the recruitment of muscle's motor units), and (2) improving range of motion through increasing blood circulation or through cutaneous mechanoreceptors stimulation (Kase et al., 1996; Kase, Wallis, & Kase, 2003). According to Kase, the KT application from origin to insertion facilitates muscle activity, while its application from

* Corresponding author. Tel.: +34 96 136 90 00, +34 617 02 43 66 (mobile); Q1 fax: +34 96 139 52 72.

E-mail addresses: jmg@uch.ceu.es (J. Martínez-Gramage), toronto092001@hotmail.com (M.A. Merino-Ramirez), juanjoamer@uch.ceu.es (J.J. Amer-Cuenca), juanfran@uch.ceu.es (J.F. Lisón).

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insertion to origin inhibits muscle activity. However, all these hypotheses have not been demonstrated so far. Indeed, there is limited scientific evidence evaluating KT effectiveness and the results are inconsistent and mixed (Williams et al., 2011). Specifically, surface electromyography (SEMG) studies to either support or oppose the use of KT are scarce and the results are controversial, with some authors reporting significant increases in SEMG muscle activity both in healthy subjects (Huang, Hsieh, Lu, & Su, 2011; Slupik, Dwornik, Bialoszewski, & Zych, 2007) and patients with anterior cruciate ligament (ACL) repair and shoulder impingement (Hsu, Chen, Lin, Wang, & Shih, 2009; Murray, 2004), and others showing no significant changes in healthy adults (Briem, Eythorsdottir, Magnusdottir, Palmarsson, Runarsdottir, & Sveinsson, 2011; Lins, Neto, Amorim, Macedo, & Brasileiro, 2013). However, being that the KT produces cutaneous mechanoreceptors stimulation an inhibitory effect might be also expected. In this sense, a recent study by Sugawara, Shimose, Tadano, Ushigome, and Muro (2013) suggested that the modulation of muscle activation in superficial and deeper regions may be induced by tactile stimulation. Specifically, these authors showed that skin friction over short head of biceps brachii results in an inhibitory response in its superficial regions, most likely due to the increase in firing rate of low-threshold cutaneous mechanoreceptors. The authors concluded that the actions of inhibitory interneurons may be influenced by cutaneous afferent input with skin stimulation.

With regard to range of motion, Nakajima and Baldridge (2013) reported inconsistent results among KT studies.

SEMG analysis of gait is considered a paradigmatic application in the study of dynamic exercise (Felici, 2004). Although an inhibition in calf muscles could be a protective mechanism to prevent cramps due to fatigue, it is surprisingly that no studies have investigated the effects of KT on calf muscles SEMG activity during gait. Therefore, the purpose of this study was to examine the effect of KT on Lateral Gastrocnemius (LG) SEMG activity and ankle range of motion during treadmill walking in a sample of healthy subjects. We hypothesized that the application of KT from insertion to origin -following Kase recommendations (Kase et al., 2003)- would (1) inhibit LG muscle motor activity, and (2) improve ankle dorsiflexion.

2. Method

2.1. Participants

Forty healthy physiotherapy students at the University Cardenal Herrera were screened for eligibility criteria. To be included, participants had to be aged 18 years or older. Those who reported history of hip, knee or foot pathology, any neurological impairment or a history of lower limb fractures were excluded.

All subjects were informed of the aims of the study and gave written informed consent before participating. The study complies with the Declaration of Helsinki and was approved by the Ethics Committee of the University.

2.2. Design

Subjects were assigned to KT or control group using a random-number generator and allocation was concealed. Both KT and control groups were tested prior to tape application and following 72 h of use (with the taping remaining in situ in KT group subjects). All measurements were conducted in the University Biomechanics laboratory. Body weight was recorded to the nearest 0.1 kg with the use of a standard beam balance scale with the subjects wearing light indoor clothing and no shoes. Height was recorded to the nearest 0.5 cm by a standardized wall mounted height board. Kinesio Tex Gold elastic sports tape (Kinesio USA, LLC, Albuquerque, NM) was used for the intervention group. The first author of this study is a certified Kinesio Taping therapist (levels KT 1 and KT 2) and applied all the taping procedures after the participants' skin had been cleaned and hair removed. To avoid bias, the second author, who was blinded to the group assignment, analyzed SEMG and kinematic data. A first strip was applied, from insertion to origin, using the I-shaped taping technique for calf muscle according to the recommendations of Kase et al. (2003). The base of the tape was applied on the surface of calcaneus bone on the sole of the foot with the subject in a relaxed prone position. Then, the anchorage was applied at a subjectively approximated tension of 50% and 75% over the Achilles tendon up to the musculotendinous junction. Afterward, a second strip was applied using a Y shaped KT technique. The distal head was applied on the base of the first strip, and the two proximal heads were attached (15%–25% of tension) following the soleus muscle and ended on the origin of medial and lateral gastrocnemius (LG) muscles below the knee joint, respectively (Fig. 1). This method of tape application was chosen because it is believed to inhibit the recruitment of muscle's motor units (Kase et al., 2003). Prior to testing, all subjects underwent a 5 min warm up consisting of walking on the treadmill (BH Fitness Columbia Pro) at the same tests speed (1.1 m/s) to become familiar with the equipment. After the familiarization stage and before data collection participants performed three plantar-flexion maximal voluntary isometric contractions (MVICs) in order to normalize muscle electromyography assessment. Participants stood unilaterally on the tested leg underneath a weightlifting stand. With the knee at 0° and the ankle in the neutral position, the height of the stand was adjusted so that the horizontal bar rested on the cervicothoracic region of each participant. The bar was subsequently secured to the base of the weightlifting stand, thus preventing movement of the unit upon the application of an external force. A pad was placed around the horizontal bar to minimize discomfort to the participant's cervicothoracic region during unilateral plantar-flexion MVIC trials. The participant was permitted to grasp the horizontal bar for upper body stabilization (Hébert-Losier & Holmberg, 2013).

2.3. Instrumentations

SEMG data acquisition was accomplished by using a 16 analog input channel MP150 acquisition unit (Biopac Systems Inc.). A twin-

Fig. 1. KT applied on gastrocnemius.

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axis electronic goniometer (TSD130A, Biometrics Ltd., Gwent, UK) was integrated to collect kinematic data simultaneously. LG SEMG signals of the tested ankle were amplified (TEL100M, BIOPAC Systems Inc., gain 1000), filtered with a band-pass of 8–500 Hz, with a common-mode rejection ratio of 110 dB and digitized with a sampling frequency of 1 KHz, using a 16-bit analog to digital converter. The amplified signal (raw SEMG) was processed using the Root Mean Square (RMS). The SEMG sensors used in this study were pre-gelled self-adhesive bipolar Ag/AgCl disposable surface electrodes of 20 mm (Infant Electrode, Lessa, Barcelona), with 2 cm interelectrode distance. SEMG electrodes were longitudinally placed on the muscle belly of the dominant leg according to SENIAM recommendations (SENIAM, 1999). The ground electrode was attached to the fibula (lateral malleolus). The selected placements did not interfere with the application of therapeutic taping or the explored movements. The electronic goniometer was used to collect ankle ROM data (plantar- and dorsiflexion). The telescopic endblock was attached with double-sided adhesive tape to the back of the heel and the fixed endblock to the posterior part of the leg, so that the axes of both endblocks were coincident.

2.4. Data analysis

SEMG and ROM data were collected during treadmill walking for a total of 3 min, and the first ten walking cycles during the third minute were analyzed using the AcqKnowledge 4.1 software for Windows. According to other authors (Felici, 2004) every walking cycle was divided into a stance phase, in which the limb is in contact with the ground, and a swing phase, in which the foot is in the air for limb advancement. The beginning and ending of each phase were defined by the following events: the stance phase lasted from initial contact to toe-off, and the swing phase from toe-off to initial contact. Fig. 2 shows synchronized SEMG and ROM signals during a walking cycle, illustrating the different events and phases.

2.5. Outcome measures

Main outcomes included the mean amplitude of the LG SEMG signal during the stance phase and the duration of the LG activity expressed as a percentage of the total time of each walking cycle. Amplitude SEMG data were normalized to the maximum signal collected during MVICs and expressed as a percentage (%SEMG). The criteria used to determine the beginning (onset) and ending (offset) of the LG relative time of activity were, respectively, abrupt and continued external activity rise and sudden and sustained activity cessation. Other variables of interest were the onset and offset times of LG activity (expressed as a percentage of the total time of each walking cycle), the ankle plantar- and dorsiflexion peaks and the cadence of gait. Mean values of the first ten walking cycles (third minute) were calculated for analysis in all variables. The cadence was calculated using the mean values of walking cycles through the third minute.

2.6. Statistical analysis

To achieve a statistically significant 3% LG SEMG amplitude reduction between the estimated mean and the sampling mean with a statistical power equal to 95% and an alpha risk of 0.01, a sample size of 13 participants per group was necessary. The sampling size was increased to compensate possible dropouts in the intervention group.

Normal distribution of the data was tested using the Kolmogorov–Smirnov test. To compare the success of randomization, preliminary chi-squared tests (gender), Mann–Whitney U test (age, %SEMG and onset), or independent sample t-test (rest of variables) were used to determine baseline differences between groups. Two-way mixed ANOVA tests were used to compare the study effects on the different variables between groups, with time (pre vs. post-72 h) serving as the within-group factor and intervention type (KT vs. control) as the between-group factor. Bonferroni's post-hoc test

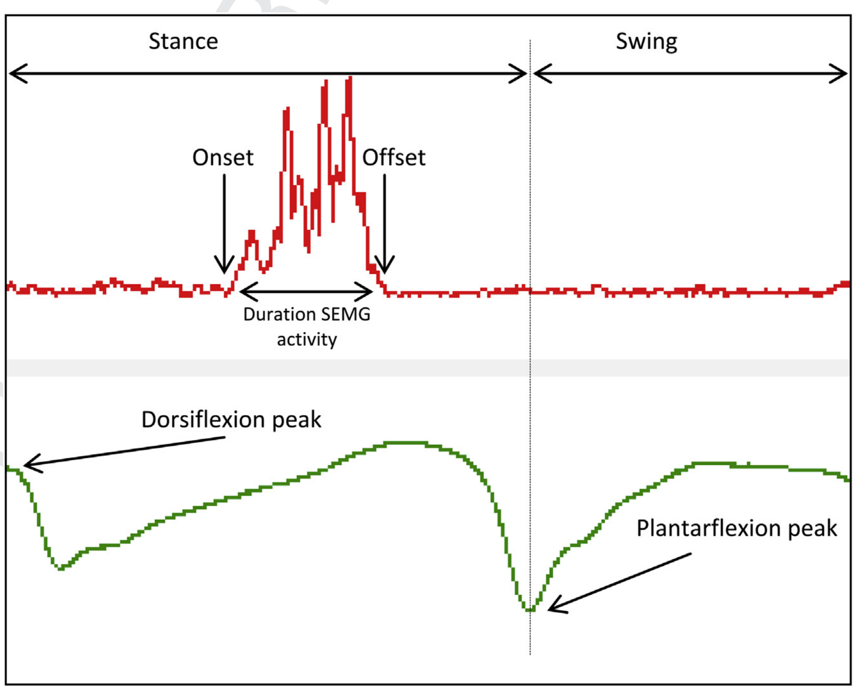

Fig. 2. Representation of the study variables during a walking cycle. Red line, SEMG signal of lateral gastrocnemius. Green line, signal from ankle kinematics. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

was used for statistical comparisons among groups. Statistical analyses were performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, Ill). Data are presented as mean ± SD. $P < .05$ was considered statistically significant.

3. Results

A schematic flowchart of the study design is shown in Fig. 3.

The general characteristics of the study population are shown in Table 1. No differences in terms of age, sex, height, weight, amplitude of the LG SEMG, duration of the LG activation, onset, offset, plantar- and dorsiflexion peaks or cadence were observed among groups at baseline.

Changes in SEMG and kinematic outcomes in KT and control groups are shown in Table 2. ANOVA only revealed a significant time × intervention interaction effect across two variables: duration of LG activation, $F(1, 33) = 4.71$, $p = .037$, $\eta = .015$; and onset $F(1, 33) = 7.92$, $p = .008$, $\eta = .037$. The results of the Bonferroni test showed significantly shorter duration of the LG activity in the KT group as compared with control group. A significant delay of the LG activation onset was disclosed in the KT group compared with control group. No statistically significant differences were noted in the remaining parameters.

4. Discussion

To the best of our knowledge, this is the first study that has investigated the effects of KT on LG SEMG activity during gait. Our results showed a 7.3% significant decrease in the duration of LG SEMG activity during treadmill walking 72 h following KT application. This reduction was largely explained by the significant delay in the onset of the muscle activity (7.7%, $p < .001$), whereas the offset did not show changes. However, the most remarkable finding was that the decreased duration of LG SEMG activity was not accompanied by a significant reduction in the amplitude as we previously hypothesized. Effectively, although the amplitude of LG SEMG activity during the stance phase decreased 1.3% in the KT group, the effect of KT did not reach neither statistical significance nor clinical relevance. Although the physiological mechanisms involved in the effects of KT extends beyond the scope of this study, the decreased duration of LG activity may be due to an inhibitory modulation of the skin stretch receptors. This inhibitory effect would be most relevant during the terminal stance of gait cycle. The

Table 1
Characteristics of the study participants at baseline.

	Control group (n = 18)	KT group (n = 18)	P
Age	22.9 (4.3)	21.8 (3)	.831
Men/Women	11/7	13/5	.725
Height (cm)	172 (9)	170.5 (8)	.563
Weight (kg)	72 (14)	65.8 (12)	.166
Amplitude LG sEMG (%)	4.7 (1.5)	5.9 (2.7)	.421
Duration of LG activation (%)	27.5 (7.5)	30 (7.9)	.340
Onset (%)	20.9 (8.3)	18.6 (6.7)	.294
Offset (%)	48.4 (3.2)	48.6 (3)	.784
Plantar-flexión peak (°)	−10.7 (4.4)	−9.1 (4.5)	.290
Dorsiflexiom peak (°)	3 (1.7)	3.6 (1.6)	.340
Cadence (steps/min)	112.3 (6.7)	111.8 (8.4)	.827

Values are mean ± standard deviations.
LG = Lateral Gastrocnemius.
P = statistical significance of the differences among groups.

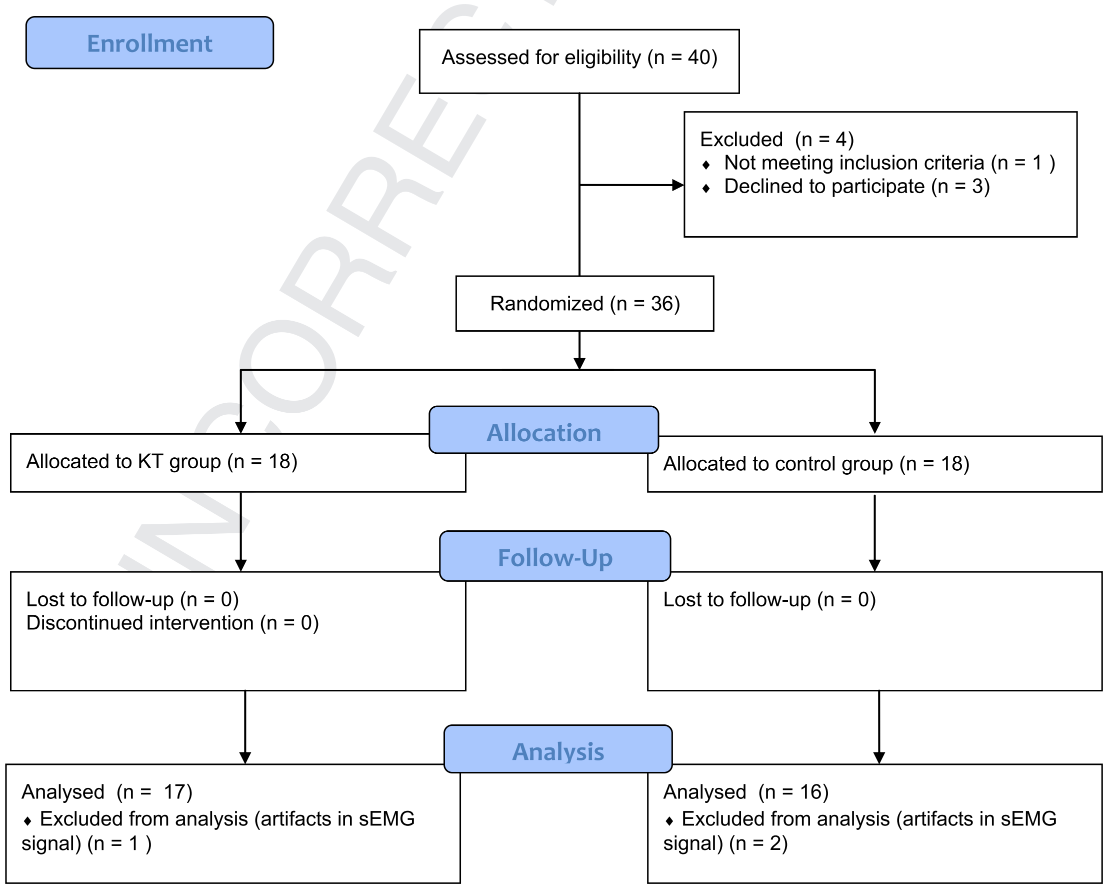

Fig. 3. Flow-diagram of subjects throughout the course of the study. Q4

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Table 2
Significance by ANOVA of the Main Effects of Time, Intervention, and Time × Intervention Interaction (T × I): Intragroup Comparisons (Pre vs Post-72 h) for the Studied Variables.

	Control group			KT group			Main effects (*P*-values)		
	Baseline	72 h	P	Baseline	72 h	P	Time	Intervention	T × I
Amplitude LG sEMG (%)	4.7 (1.5)	3.9 (1.5)	–	5.9 (2.7)	4.6 (1.3)	–	.004	.107	.412
Duration of LG activation (%)	27.5 (7.5)	25.7 (3.6)	.363	30 (7.9)	22.7 (4.4)	.000	.001	.884	.037
Onset (%)	20.9 (8.3)	22.3 (4.9)	.453	18.6 (6.7)	26.3 (3.5)	.000	.000	.893	.008
Offset (%)	48.4 (3.2)	48 (2.3)	–	48.6 (3)	49 (3.1)	–	.991	.416	.602
Plantar-flexión peak (°)	−10.7 (4.4)	−10.4 (4.6)	–	−9.1 (4.5)	−10.6 (4.3)	–	.446	.584	.234
Dorsiflexiom peak (°)	3 (1.7)	3.8 (1.5)	–	3.6 (1.6)	3.3 (2.3)	–	.385	.965	.094
Cadence (steps/min)	112.3 (6.7)	110 (7.9)	–	111.8 (8.4)	110.5 (7.5)	–	.106	.988	.620

Values are mean ± standard deviations.
LG = Lateral Gastrocnemius.
P = statistical significance of the differences among groups.

stretch effect of the KT should be maximum during this period of time because the ankle moves from neutral to maximal dorsiflexion (Perry, 1992). Hence, the duration of LG activity could be an early and more sensitive parameter than EMG amplitude to reveal the underlying KT-related physiological processes.

Our SEMG activity results are consistent with those reported by other researchers. Lins et al. (2013) concluded that application of KT to quadriceps femoris muscles did not significantly change SEMG activity during peak concentric and eccentric torque in healthy women. Briem et al. (Briem et al., 2011) concluded that KT had no significant effect on mean or maximum fibularis longus SEMG muscle activity during a sudden inversion perturbation in male athletes. On the contrary, KT has been shown to facilitate muscle effort in a number of studies. Huang et al. (2011) reported an increase in SEMG muscle activity of the medial gastrocnemius during a maximal vertical jump immediately following KT (Y shaped KT application from origin to insertion for calf muscle) in healthy adults. Hsu et al. (2009) reported increased lower trapezius SEMG activity in the 60-30° arm lowering phase when compared with placebo after KT application (from origin to insertion) in a sample of patients with shoulder impingement. Murray (2004) has shown an increase in quadriceps SEMG activity following KT application in patients treated with surgical reconstruction of the ACL, and Slupik et al. (2007) also found increased recruitment of muscle's motor units 24 h after placement of KT on the quadriceps muscle, and the maintenance of this effect for another 48 h following removal of the tape.

Regarding ankle ROM and gait cadence, our results also showed no significance differences between groups. In a recent meta-analysis Williams et al. (2011, p. 154) concluded that there are “inconsistent ROM outcome results, with small benefits or trivial results across numerous joint measurements”. On the other hand, no evidence was found connecting the KT application to long-term improved ROM (Kalron and Bar-Sela, 2013). As recently pointed out by Nakajima (Nakajima & Baldridge, 2013) the disagreement among studies in relation to performance outcomes -including SEMG activity and ROM-may be attributed to 1) the different experimental designs: area to be taped, KT application technique, measurement instruments, outcome measures; 2) the duration of KT application: immediate vs. post-24/48/72 h/etc. effects; 3) the individual physical fitness: sedentary, amateurs or professional athletes; and 4) the presence or not of any disorder in the studied subjects. Hence, our results showed that KT, applied 1) from insertion to origin, 2) during 72 h, and 3) in healthy adults, does not have a significant impact on the amplitude of LG SEMG activity and ROM during gait. This finding could be relevant because this tape is erroneously used by many athletic trainers and physical therapists with the purpose of improving muscular function or ROM performance.

The results of this study are subject to limitations. First, the participants were a convenience sample that included only healthy individuals with no lower limb injuries. Therefore, the results of the present study may not be applicable to individuals with pathology. Nevertheless, considering the fact that KT is related to several therapeutic effects, studying healthy individuals allowed us to ensure reliability of the results and easily establish a baseline for measurement. On the other hand, studies attending to musculo-skeletal outcomes in healthy participants may have implications for the prevention of sporting injuries where the decrease in SEMG activity would be relevant (i.e., control muscle cramping). To the same extent, the results of the study must be viewed in context of the controlled experimental set-up. Studies conducted in real-work settings may help researchers to better understand the potential benefits of KT. Finally, we investigated the short-term impact of KT application and hence the results cannot be extrapolated to longer periods of time.

Despite these limitations, this study had several strengths: it was the first study to examine the effects of KT during treadmill walking under controlled conditions and included a sample large enough to explore SEMG muscle responses. The activity explored (gait) is the paradigmatic example of SEMG applied to the study of dynamic exercise, reinforcing the reliability of the results. Subjects were randomly assigned to KT or control groups and, where appropriate, this study provides information on the size of the observed effects.

5. Conclusion

The results of this study demonstrate that KT does significantly shorten the duration of the LG activity during gait when applied 72 h in healthy adults. However, this effect was not accompanied by a significant reduction in the amplitude of LG SEMG activity. Future research should be conducted on pathological populations to ascertain if KT could affect the studied variables.

Competing interests

None declared.

Ethics approval

The University's Research Ethics Committee of University CEU Cardenal Herrera approved this study. All participants gave written informed consent before data collection began.

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