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A sample of 34 duathlete volunteers was recruited from the competitors in a duathlon sprint. Calf pain and extensibility measures were obtained at baseline, immediately after taping, and 10–15 minutes after competition. Kinesio tape (KT) was applied on the calf of duathletes 20–90 minutes before the competition, only on one of their legs, with the other leg acting as a control. Repeated measures ANOVA results on calf extensibility did not show statistically significant differences [$F(2) = 0.180$; p $= 0.836$]. Nevertheless, Friedman test results on calf pain showed statistically significant differences [$\chi^2(2) = 10.111$; p $= 0.006$]. Additionally, post hoc *pairwise comparison showed statistically significant differences from baseline to after competition (*p *= 0.006). Applying KT on calves seems to reduce muscle pain produced by the competition among duathletes with no apparent musculoskeletal disorder. Kinesio tape (KT) application, however, does not affect the calf extensibility immediately and after a duathlon competition.*

KEYWORDS *taping, ankle, range of motion, flexibility, Numerical Pain Rating Scale*

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INTRODUCTION

During the 2008 Beijing Olympics, several athletes were seen wearing Kinesio tape (KT) on their shoulders, knees, ankles, elbows, wrists, and other body parts. Since then, athletes across all sports and in different parts of the world use this athletic tape (Bassett, Lingman, & Ellis 2010; O'Sullivan & Bird, 2011; Willians, Whatman, Hume, & Sheerin, 2012). The elimination of perspiration and freedom of motion are particular properties of KT that have been shown to be desirable to athletes (Huang, Hsieh, Lu, & Su, 2011).

There are many suggested benefits of KT, including decrease of pain (Gonzalez-Iglesias, Fernandez-de-Las-Penas, Cleland, Huijbregts, & Del Rosario Gutierrez-Vega, 2009; Paoloni et al., 2011), increasing proprioceptive facilitation (Jaraczewska & Long, 2006), muscle facilitation (Firth, Dingley, Davies, Lewis, & Alexander, 2010; Slupik, Dwornik, Bialoszewski, & Zych, 2007), increasing muscular strength (Vithoulk et al., 2010), improving pain-free active range of motion (ROM; Thelen, Dauber, & Stoneman, 2008), and increasing active ROM (Yoshida & Kahanov, 2007).

Elastic taping applied on the triceps surae has been commonly used by athletes to improve the performance in their lower extremities (Huang et al., 2011). Kinesio tape (KT) is also gaining popularity with regard to sports performance, especially in sports that require repetitive, high-intensity muscular effort, and eccentric loading (O'Sullivan & Bird, 2011). The unique qualities of the KT method may have multiple uses in sports injury prevention and likewise on overall performance (O'Sullivan & Bird, 2011; Vithoulk et al., 2010).

Although there are several suggested benefits of KT on athletic performance, according to the studies cited above, researchers found that the use of KT did not produce any improvement on muscular strength (Firth et al., 2010; Fu et al., 2008), on the ROM (Merino-Marban, Fernandez-Rodriguez, Lopez-Fernandez, & Mayorga-Vega,2011; Salvat & Alonso, 2010) or decreasing the delayed onset of muscle soreness (Shoger, Nishi, Merrick, Ingersoll, & Edwards, 2000). Despite a lack of clinical data to support KT, the accumulation of anecdotal evidence has prevailed over scientific evidence (Bassett et al., 2010; Willians et al., 2012).

Research based on samples of healthy athletes in order to test the effect of KT on some aspect of performance is scarce and contradictory (Chang, Chou, Lin, Lin, & Wang, 2010; Fu et al., 2008) and has been conducted in laboratory settings. To our knowledge there are no studies examining the effects of KT during a sport competition. Consequently, the purpose of this study was to examine the effect of KT application immediately and after a duathlon competition on calf pain and extensibility in duathletes.

METHODS

Participants

A sample of 34 duathlete volunteers (six females and 28 males; mean age 35.32, $s = 11.23$ years; mean body height 174.71, $s = 6.87$ cm; mean body mass 69.12, $s = 9.52$ kg; mean body mass index 22.56, $s = 2.06$ kg/m^2) were recruited from the competitors in a duathlon sprint (5 km running + 20 km cycling + 2.5 km running). The participants were recreational duathletes involved in regular training and competition (mean training time per week 12.58, $s = 4.49$ hours, mean competition 5.41, $s = 5.03$ years). None of the participants reported any form of musculoskeletal disorder at the time of testing. Participants were thoroughly informed of the protocols and procedures before their participation, and written informed consent was obtained from all of them. The study was approved by the Ethics and Research Committee of the University of Malaga.

Procedures

The intervention took place on March 13, 2011, the day of the celebration of the XI Duathlon at Torre del Mar (Malaga, Spain). The competition started at 10:00 a.m. and consequently the delivery of bib numbers started 2 h before. While the athletes were in line waiting to pick up their bib, they were fully informed about the purpose and procedures of the study and were asked to participate. Out of the 202 participants in the competition, 34 volunteered to participate in the study (Figure 1).

The outcome measures for this study consisted of a Numerical Pain Rating Scale (NPRS; Gonzalez-Iglesias et al., 2009) and ankle ROM (Draper, Anderson, Schulthies, & Ricard, 1998). All measures were obtained at baseline (preKT), immediately after taping (postKT), and 10 to 15 minutes after finishing the duathlon competition (postRace). The KT was applied on the calf of duathletes between 20 to 90 minutes before the competition. The KT was applied only on one leg of every participant (experimental leg, EL) while the other leg acted as a control (control leg, CL). The KT was applied alternating right and left leg of the athletes when going through measurements. All duathletes received the KT application by the primary author, a certified KT practitioner.

Calf Pain

The NPRS (0 = no pain; 10 = maximum pain) was used to record the duathlete's current level of calf muscle pain. Each participant was asked to rate their current level of pain. The participant was shown a line drawn on a sheet with "no pain" marked at one end of the scale and "maximum pain"

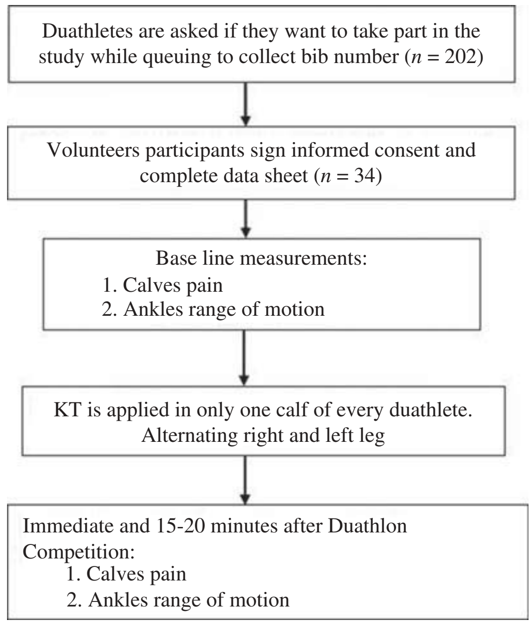

FIGURE 1 Flow diagram of subjects throughout the study.

marked at the other. The NPRS is a valid, reliable tool and is sensitive to pain (Williamson & Hoggart, 2005).

Calf Extensibility

Ankle dorsiflexion ROM was used to record the duathlete's calf extensibility. Ankle dorsiflexion ROM was measured in the weight-bearing position using an inclinometer (AcuAngle, Japan; Figure 2). This measurement was accomplished by placing the device on the posterior aspect of the calf while the participant was standing erect, so that the calf muscle was at a 90° angle to the floor. To insure consistent placement of the inclinometer, a semipermanent mark was drawn on each participant's calf muscle and used throughout the study. While maintaining the knee in full extension and the foot flat on the ground, the participant shifted the body over the foot as far as possible while the needle on the inclinometer moved to measure maximal dorsiflexion ROM (Draper et al., 1998). All ROM measurements were collected by the same investigator. All ROM measurements were performed twice, and the average was recorded for data analysis.

Taping Application

A 5 cm wide kinesio tape (Kinesiology tape, Korea) was applied to the participants' calf using the I-shaped taping technique (Kase, Wallis, & Kase, 2003). The base of the tape was placed without stretching with the participant

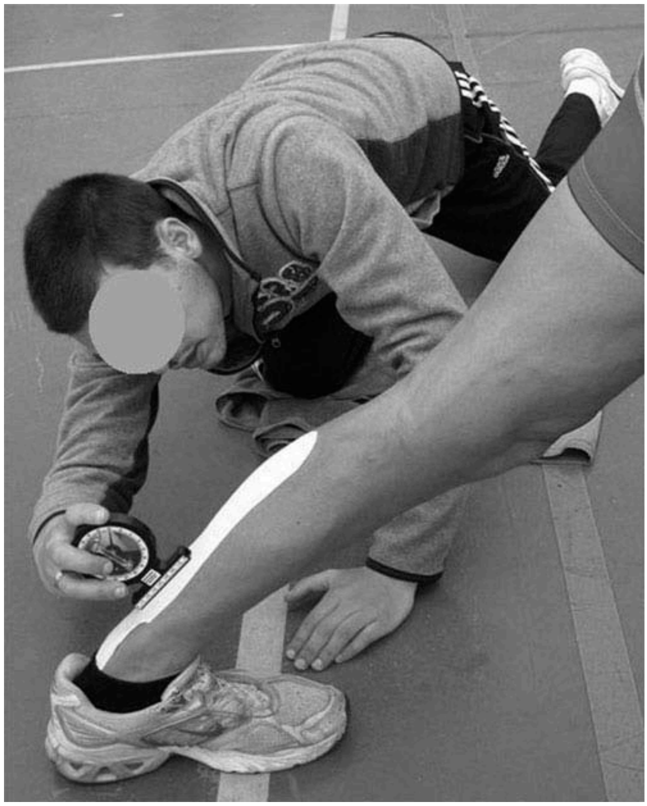

FIGURE 2 Ankle dorsiflexion ROM measurement.

in a neutral body position, just distal to the insertion of the muscle. Then a functional strip was applied on the stretched muscle belly, maintaining the original 10% tape prestretching. Next, the anchorage was applied without stretching, just proximal to the insertion of muscle in a neutral body position (Kase et al., 2003). The CL went through the same procedure, including the stretching, but the KT was not applied. All KT procedures were done by the same investigator.

Statistic Analysis

Descriptive statistics (means and standard deviations) of age, height, body mass, body mass index, training hours per week, years of competition, and the results obtained in the NPRS and the ankle ROM were calculated. A repeated measures analysis of variance (ANOVA) with leg differences (experimental leg – control leg) on ankle ROM values (preKT, postKT, postRace) was used. For post hoc analysis, α values were corrected using the Bonferroni adjustment. As the results obtained in the NPRS did not follow a normal distribution, a nonparametric statistic was applied. The Friedman test with leg differences (experimental leg – control leg) on NPRS values (preKT, postKT, postRace) was used. For post hoc analysis, Wilcoxon tests with Bonferroni adjustment over α values were applied. The Hedges´ *g* effect size (ES) was used to determine the magnitude of treatment effects (Hedges, 2008). The reliability of the ankle dorsiflexion ROM test was estimated using the intraclass correlation coefficient from two-way ANOVA (Shrout & Fleiss, 1979), as well as the 95% confidence interval. Statistical analysis was performed using SPSS 15.0 for Windows (SPSS Inc., Chicago, IL, USA). The level of statistical significance for all tests was set at $p < 0.05$, except for the Wilcoxon test with Bonferroni adjustment that was set at $p < 0.017$.

RESULTS

The mean values and standard deviations obtained of the calf extensibility, as well as the results of repeated measures ANOVA, are in Table 1. The results of the ANOVA in the leg differences on ankle ROM values did not show statistically significant differences [F(2) = 0.180; $p = 0.836$]. Likewise, for post hoc pairwise comparisons with Bonferroni adjustment statistically significant differences were not found ($p > 0.05$). The reliability ankle dorsiflexion ROM test was 0.90 (0.84–0.94).

The mean values and standard deviations obtained of the calf pain, as well as the results of the Friedman test, are in Table 2. The results of the Friedman test in the leg differences on NPRS values showed statistically

TABLE 1 Effects of Kinesio Taping on Calf Extensibility (°)

Group	PreKT (1) (M ± SD)	PostKT (2) (M ± SD)	PostRace (3) (M ± SD)	ANOVA[a]		
				F	gl	p
EL	36.0 ± 6.7	37.4 ± 6.5	37.2 ± 6.4	0.180	2	0.836
CL	35.3 ± 5.4	36.9 ± 5.3	36.7 ± 5.6	ES (1-2)	ES (2-3)	ES (1-3)
Difference[b]	0.8 ± 3.1	0.5 ± 2.9	0.5 ± 3.4	0.05	0.01	0.22

*Change statistically significant from preKT to PostRace with Wilcoxon test ($p < 0.017$).
Note. M = mean; SD = standard deviation; EL = experimental leg; CL = control leg; ES = Hedges´ *g* effect size; [a]Repeated measures analysis of variance test; [b]Difference between legs (experimental leg – control leg).

TABLE 2 Effects of Kinesio Taping on Calf Pain (0–10 Scale)

Group	PreKT (1) (M ± SD)	PostKT (2) (M ± SD)	PostRace (3) (M ± SD)	Friedman test		
				χ^2	gl	p
EL	1.9 ± 1.7	1.2 ± 1.4	2.2 ± 2.4	10.111	2	0.006
CL	1.8 ± 1.7	1.3 ± 1.5	3.1 ± 2.4	ES (1-2)	ES (2-3)	ES (1-3)
Difference[b]	0.1 ± 0.6	−0.1 ± 0.9	−0.8 ± 1.8*	− 0.07	− 0.57	− 0.54

Note. M = mean; SD = standard deviation; EL = experimental leg; CL = control leg; ES = Hedges´ *g* effect size; [a]Difference between legs (experimental leg – control leg).

significant differences [$\chi^2(2) = 10.111$; $p = 0.006$]. Additionally, post hoc pairwise comparison with Wilcoxon test showed statistically significant differences from preKT to postRace ($p = 0.006$). Nevertheless, from preKT to postKT and from postKT to postRace, statistically significant differences were not found ($p > 0.017$).

DISCUSSION

The purpose of this study was to examine the effect of KT application on calf pain and extensibility immediately and after a duathlon competition. According to the present results, the KT application does not seem to affect the calf extensibility either immediately or after a competition among duathletes with no apparent musculoskeletal disorder. Nevertheless, current results suggest that KT application may reduce calf pain produced by a duathlon competition.

Calf Extensibility

The present study did not find any effect of KT on the ankle ROM immediately after application or after the completion of a duathlon competition. Along the same lines, previous controlled studies did not find any affect of KT on the ROM immediately after application. Merino-Marban and colleagues (2011) studied the acute effect of KT on the extensibility of the hamstring muscle on 43 university students. All participants had both legs tested under three different randomly ordered conditions (KT, placebo tape, and control) using the Passive Straight Leg Raise Test. No statistically significant differences were found among the three study conditions. The same was true for Salvat and Alonso (2010), who studied the acute effect of KT on trunk flexion. The 33 participants were randomly distributed into three groups: KT, conventional tape, and placebo tape. No statistically significant differences were found between groups based on their sit and reach scores.

On the contrary, Lee and Yoo (2012) performed Achilles tendon and soleus and gastrocnemius muscles complex taping to evaluate the effects of KT on an amateur badminton player with chronic Achilles tendon pain. The angle of active dorsiflexion without pain increased. In the study of Thelen et al. (2008), the KT immediately improved the patients' pain-free shoulder ROM. Gonzalez-Iglesias et al. (2009) found that patients with acute whiplash exhibited statistically significant improvements in cervical ROM immediately following application of the KT. Yoshida and Kahanov (2007) found a significant increase in active lower back flexion ROM in 30 healthy university students after KT application on the lower back.

The results on the ROM from the different studies are contradictory. It should be noted that except for the study of Yoshida and Kahanov (2007) conducted with apparently healthy participants, in the investigations that show improvements in ROM, the samples were injured individuals and the studies were not controlled. In contrast, in line with the present study, in previous studies where the KT did not affect the ROM, the samples were composed of healthy participants and were controlled. Hence, KT application might be only effective in increasing ROM among chronic injured individuals. Additionally, because there is a lack of randomized controlled experimental studies, we should be cautions with these positive previous results.

Calf Pain

The present results suggest that KT application may reduce calf pain produced by a competition among duathletes with no apparent musculoskeletal disorder. After the duathlon competition, both legs experienced an increase in the intensity of pain. Pain increase, however, was much greater in the CL. Therefore, it seems that the KT is capable of maintaining to some extent muscle soreness after strenuous physical activity like when participating in a duathlon competition. In this line, according to Cohen (1988), the ES showed a moderate effect of KT reducing from baseline to postRace for the EL (ES = |0.54|).

In line with the present study, the positive effect of KT in pain reduction can be observed in different studies. Kaya, Zinnuroglu, and Tugcu (2011) compared KT with physical therapy modalities in 55 patients with shoulder impingement syndrome. The rest, night, and movement mean pain scores of the KT group were significantly lower at the first week examination as compared with the physical therapy group. They recommend KT, especially when an immediate effect is needed. Gonzalez-Iglesias et al. (2009) demonstrated that patients with acute whiplash who received KT exhibited statistically significantly reductions in neck pain immediately following the application of the KT evaluated by an 11-point numerical pain rating scale. When Paoloni et al. (2011) applied KT to 39 chronic lower back pain patients, it led to pain relief shortly after its application. They recommend KT for immediate and acute pain control. Lee and Yoo (2012) found that a load-induced pain assessment score decreased after applying KT over triceps surae and Achilles tendon on a 22-year-old male amateur badminton player.

On the other hand, there are also studies in which KT has demonstrated no effect on pain. In the study of Thelen et al. (2008) the KT had no effect on pain in college students with shoulder pain. There were no changes to pain when Firth et al. (2010) applied KT over the Achilles tendon in 26 healthy adults and 29 individuals with Achilles tendinopathy. Garcia-Muro, Rodriguez-Fernandez, and Herrero-de-Lucas (2010) in a case report document the results achieved with KT as the exclusive therapeutic procedure for the treatment of a patient with shoulder pain of myofascial origin. It is highly significant that intensity values of pain, either subjective

(Visual Analog Scale) or objective (algometry), did not change between the two first measurements.

Again, the results of the different studies are contradictory. It should be highlighted that, in the investigations that show no effect on pain, the samples were injured individuals and not controlled studies. In contrast, one of the studies that found significant decrease of pain was controlled (Paoloni et al., 2011). A difference between the present study and others is the etiology of pain. Whereas in the others studies the pain is caused by a lesion, in the present research it is a postexertion pain.

The exact mechanisms by which KT works is not clear yet, but it has been suggested that the effects are both proprioceptive and mechanical. The application of KT might stretch the skin, by applying pressure to the skin, and this external load might stimulate cutaneous mechanoreceptors, causing physiological changes and increasing flexibility of soft tissues in the taped area (Yoshida & Kahanov, 2007). Taping will gradually provide stimulation with a gentle, light stimulus to the epidermis, to the dermis, and to the fascia. This gentle reaction provides a fast, effective analgesic effect (Kase, 2011). Some researchers highlight that the application of KT reduces the levels of pain experienced by loosening the muscular fascia (Lee & Yoo, 2012). The fascia is innervated by free nerve endings that convey nociceptive neural signals (Schleip, Zorn, & Klingler, 2010). Pain relief is believed to be mediated by a reduction in the mechanical load on free nerve endings within the fascia (O'Sullivan & Bird, 2011).

CONCLUSION

Applying KT on calves seems to reduce muscle pain produced by the competition among duathletes with no apparent musculoskeletal disorder. Kinesio tape (KT) application does not, however, affect the calf extensibility immediately and after a duathlon competition.

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