The Effect of Kinesiotape on Function, Pain, and Motoneuronal Excitability in Healthy People and People With Achilles Tendinopathy

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Objective: To investigate the effect of kinesiotape on hop distance, pain, and motoneuronal excitability in healthy people and people with Achilles tendinopathy (AT).

Design: Within-subject design.

Setting: An academic health science center, which is an acute London National Health Service trust.

Participants: With ethical approval and informed consent, a convenience sample of 26 healthy people and 29 people with AT were recruited. Seven participants were lost after functional testing, leaving 24 participants in each group.

Interventions: Kinesiotape applied over the Achilles tendon.

Main Outcome Measures: The single-leg hop test and visual analog scale were measured with and without the tape. Using the Hoffman (H) reflex, change in motoneuronal excitability of calf muscles was measured before tape application, with the tape on and after its removal.

Results: There were no changes to hop distance when tape was applied ($P = 0.55$). Additionally, there were no changes to pain ($P = 0.74$). The H reflex amplitude of soleus and gastrocnemius increased in the healthy group after its removal ($P = 0.01$ and $P = 0.03$, respectively), whereas the H reflex remained unchanged in people with AT ($P = 0.43$ and 0.16, respectively).

Conclusions: Calf muscles were facilitated by kinesiotape in healthy participants. Despite this, there was no change to hop distance. Kinesiotape had no effect on hop distance, pain, or motoneuronal excitability in people with AT. These results do not support the use of kinesiotape applied in this way for this condition.

Key Words: Kinesiotape, Achilles, function, pain

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INTRODUCTION

Kinesiotape was first used in 1973 by Dr Kenzo Kase[1] and was officially introduced to the United Kingdom in 2004. Having increased in popularity since the Beijing 2008 Olympics, it is now applied on people taking part in many different sports[2] and being used in clinical practice for people with various pathologies.

Kinesiotape is designed to mimic the qualities of human skin through its specific thickness and high elasticity.[1] Numerous different effects are hypothesized, which include effects on strength, control, and performance, as well as reduction in pain, prevention of injury, and promotion of circulation and healing.[1] It is surprising that even though kinesiotape is being increasingly used, there is a paucity of evidence demonstrating its effectiveness. There has been some exploration of the effect of this tape on strength, control, and pain with conflicting results. For example, Slupik et al[3] demonstrated an increase in peak torque at 24 hours and electromyographic activity at 72 hours in the medial quadriceps of healthy individuals after application of the tape. In contrast, Fu et al[4] demonstrated that concentric and eccentric muscle strength of the quadriceps and hamstrings in healthy people was uninfluenced by kinesiotape. Turning to the effect on control, proprioceptive effects of kinesiotape have been investigated using joint angle replication. Once again, the evidence is conflicting; Murray and Husk[5] demonstrated an improvement in the joint angle replication of ankle with application of kinesiotape, and Chen and Lou[6] demonstrated reduced variability of position matching, whereas Halseth et al[7] found no change to ankle joint angle replication. Finally, despite the claims of analgesic effects, the evidence to date is again limited. Thelen et al[8] and Gonzalez-Iglesias et al[9] investigated people with shoulder pain and an acute whiplash disorder, and they both reported an initial reduction in pain with application of kinesiotape. However, over a longer time frame, the results were mixed. For example, a reduction in pain was maintained at 24 hours in acute whiplash disorder,[9] but for people with shoulder pain, the effect was lost at 3 days after the initial application.[8]

Courses teaching the application of kinesiotape are now available. Consequently, many application procedures are advocated for different pathologies and to impart different effects, which can be in contrast to the pattern of application, as well as the physical properties of other tapes.[10] One pathology where kinesiotape is thought to be of benefit is Achilles tendinopathy (AT).[1] Achilles tendinopathy can be a painful and debilitating condition. It often has an insidious onset with localized tendon pain associated with tendon loading activities and morning ankle stiffness.[11] Other physical treatments include eccentric loading, tendon mobilizations, sports-specific rehabilitation, stretching,[12–16] and taping. Stretch tape has been used to limit dorsiflexion of the foot for the patient with an Achilles tendon strain, and rigid tape has been used to limit all movements to give the Achilles tendon "support."[10] However, to date, there is no research exploring the effects of kinesiotape applied to people with AT. Therefore, this study aimed to investigate the immediate effects of kinesiotape on a functionally relevant task, pain, and calf muscle excitability in healthy subjects and people with AT.

METHODS

A within-subject design was used after gaining ethical approval from Hammersmith and Queen Charlotte's and Chelsea Research Ethics Committees (reference number 09/H0707/3). Before inclusion, participants gave signed and witnessed informed consent.

Participants

A convenience sample of 26 healthy people was recruited by advertising for staff and students at the Imperial College Healthcare NHS Trust. People with a history of lower limb trauma or pathology were excluded. The dominant leg of these participants was used for this study. Dominance was determined by a modified version of a test outlined in Vauhnik et al.[17] Each healthy subject was asked which leg they would use for the following: (1) kicking a ball, (2) tracing the shape of a diamond on the floor, and (3) stamping on the representation of a bug. The leg that the subject would use for 2 or more of the 3 tasks was deemed the dominant leg.

Twenty-nine people thought to have AT were recruited using advertisements on running club Web sites and from the Departments of Physiotherapy and Podiatry at the Imperial College Healthcare NHS Trust. Inclusion criteria for the AT group were palpable tenderness over the Achilles tendon, morning ankle stiffness, and a limitation to functional activities such as running or walking due to pain or discomfort on the Achilles tendon. In an attempt to exclude people with an undiagnosed Achilles tendon tear, people who had suffered a sudden onset to their pain were excluded. In addition, and to recruit a more homogeneous group, people with a history of Achilles surgery, a known tear, or undefined symptoms were also excluded. Where people had bilateral Achilles symptoms, the leg used for the study was the one that the subject suffered with the most pain.

Taping Technique

The tape was applied by 4 senior physiotherapists, familiar with using tape and specifically trained to apply this tape using the prescribed technique. As defined by Kase et al,[1] a kinesiotape tendon correction technique was used (5-cm width; Vivomed, Downpatrick, Northern Ireland). This method of tape application was chosen because it is believed to "stimulate" the central nervous system.[1] The tape was applied with the subject prone and with the foot over the end of the plinth. First, the length of the tape was cut to size by estimating the distance from the distal end of the plantar aspect of the calcaneus to the distal end of the gastrocnemius muscle belly. The ends of the tape were then rounded for application. The subject was asked to actively dorsiflex the ankle to the end of range and then one end of the tape was applied to the base of the calcaneus under no tension. The tape was then applied at a subjectively approximated tension of 50% and 75% over the Achilles tendon up to the musculotendinous junction. At the musculotendinous junction, the tape was applied with 15% to 25% of the available tension. The top end of the tape was then applied under no tension. Finally, the tape was rubbed by the tester to improve adherence to the skin (see Figure 1A).

Measures

The severity of the functional deficit in the AT group was assessed using the Victorian Institute of Sport Achilles (VISA-A) tendon scale. In this outcome measure, a high score indicates a low functional deficit. This questionnaire has been shown to be a valid and reliable index of the clinical severity of AT.[19]

The effect of kinesiotape on function and performance was measured using the single hop test as described by Reid et al.[20] This test was chosen due to its ability to provide reliable and repeatable outcomes. The test was repeated with and without the tape in place, and this order was randomized using a random number generator (Microsoft Excel 2003; Microsoft Corporation, Redmond, Washington). Participants were instructed to hop as far as possible, and successful attempts were defined when they were able to hold the single-footed landing position for at least 2 seconds. To reduce practice effects, participants were first allowed to practice until they were happy with the method. After this, an average of 3 successful attempts for each condition was used for data analysis. Measurement was made to the nearest centimeter from the distal tip of the first phalanx to the start position.

A 10-cm visual analog scale (VAS) was used to assess the level of pain on the day of testing; before tape application, with the tape in place, and finally after tape removal. The VAS has been shown to be a valid, repeatable, and reliable tool for the assessment of pain.[21]

Calf muscle excitability was assessed by evoking the Hoffman (H) reflex of the soleus and gastrocnemius muscles. The H reflex testing has been long established in the literature and has been used previously by this group to explore the effect of tape on motoneuronal excitability (see Alexander et al[22] for a detailed explanation of this protocol). A change to motoneuronal excitability can be assessed by demonstrating a change in the amplitude of an H reflex without a change to the amplitude of a motor (M) response. To record these responses, electromyographic activity of the lateral soleus and medial portion of gastrocnemius were recorded using surface electrodes (Ambu Q-10-A; Ambu UK Ltd, St Ives, United Kingdom) placed 3 cm apart located in traditional positions.[18] The data were then amplified (Digitimer NL844), isolated (Neurolog NL820; Digitimer, Welwyn Garden City, United Kingdom), filtered with a bandwidth of 30 Hz to 6 kHz (Neurolog NL125), converted to a digital signal (CED 1401), and stored for later analysis using Signal v3 software (Cambridge Electronic Design; Cambridge, United Kingdom).

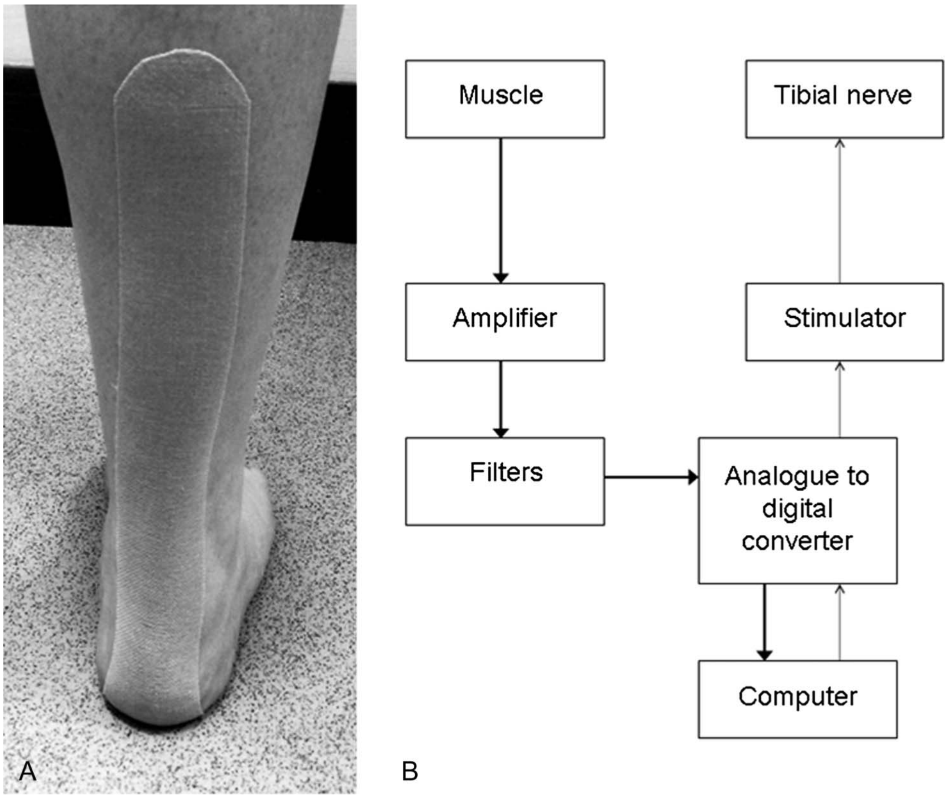

FIGURE 1. A, A photograph showing the location of the kinesiotape applied to the skin. A neutral beige color of kinesiotape was always used to control the potential for an effect of color. B, A diagrammatic representation of the recording circuit (thick arrows) and stimulating circuit (thin arrows). This diagrammatic representation is modified from Alexander et al.[18] Reprinted with permission from Elsevier.

Electrical stimulation to the tibial nerve was delivered using an anode (a rectangular flat electrode, smeared with electrode gel) taped to the distal surface of the hamstrings. To ensure accurate placement of the cathode, a roving electrode was initially used to find the position of the tibial nerve in the popliteal fossa. Once this position was established by evoking a response in the calf muscles, the roving cathode was replaced with a self-adhesive, pre-gelled electrode (Ambu Q-10-A) positioned on the skin over the tibial nerve. Every 5 seconds, 1-millisecond square wave pulses were delivered percutaneously to the tibial nerve (Digitimer DS7A stimulator). Figure 1B illustrates the details of this process.

The intensity of stimulation was increased until a mid amplitude H reflex could be defined. A mid amplitude H reflex was defined as one with an amplitude halfway up the recruitment curve. This amplitude was chosen to ensure that the amplitude of the H reflex was standardized, sensitive to change, and able to either increase or decrease in size in response to tape application or removal. Participants were excluded if no H reflex could be evoked or if no M response from at least 1 muscle accompanied a test H reflex. A minimum of 40 stimuli were delivered during each of the following 3 conditions: (1) before tape was applied, (2) with tape applied, and (3) immediately after the tape was removed. The peak-to-peak amplitude of the M responses from one muscle and H reflexes from both muscles were collected for later analysis. To effectively analyze the response of the H reflex and to interpret any changes in the H reflex as being in response to a change in motoneuronal excitability, only the H reflexes accompanying M responses with consistent amplitudes were used in the analysis. This is because a stable M response reflects a stable stimulus applied to the tibial nerve; therefore, variability in the amplitude of an M response reflects variability in the stimulus delivery, which could lead to a misinterpretation of motoneuronal excitability. Therefore, the data were examined for erroneous M responses. These responses and their accompanying H reflexes were filtered out until a 1-way analysis of variance (ANOVA) showed no significant difference between the amplitude of the M responses before tape was applied, with the tape applied, and after the tape was removed. The amplitude of the H reflexes accompanying the consistent M responses was then used for analysis (see Alexander et al 2003[22] for further details of this process). The protocol was carried out by investigators who were not blind to the aims of the study.

Statistical Methods

Descriptive statistics were calculated for all data. Data were then analyzed to assess for normal distribution using the Kolmogorov–Smirnov test and normalized where possible and if appropriate. Hop distance and H reflex amplitude were compared using a 2-way repeated ANOVA (group × tape state). The VAS scores were compared using a 1-way repeated measures ANOVA. Post hoc testing was completed using a Bonferroni test, where indicated. For the H reflexes, the ANOVA was populated using the mean H reflex amplitude for each condition and subject. A significance level of 0.05 was used as the critical value, and SPSS version 17.0 (SPSS, Inc, Chicago, Illinois) used for all data analysis.

RESULTS

There were 4 male and 22 female participants in the healthy group who ranged in age between 21 and 44 years [27.6 ± 5.4 (mean ± SD)]. There were 17 male and 12 female participants in the AT group who ranged in age between 31 and 68 years (44.5 ± 10.7 years). The hop test was successfully carried out for all participants. Additionally, VAS and VISA-A scores were collected for all participants in the AT group. The VISA-A scores for the AT group ranged from 21 to 94 (60 ± 18), revealing a wide range of levels of disability within the group. After further testing, 7 participants were lost as the H reflex or M response could not be analyzed. Therefore, motoneuronal excitability was analyzed in 24 healthy and 24 AT participants.

There was no difference to hop distance when tape was applied ($P = 0.55$). The healthy group's hop distance was 130 ± 29 cm without tape and 130 ± 27 cm with tape applied. Unsurprisingly, the AT group did not hop as far as the healthy group ($P < 0.0005$). The AT group's hop distance was 87 ± 29 cm without tape and 90 ± 32 cm with tape applied. It is interesting to note that if the data were analyzed by comparing the first set of hop attempts to the second set, irrespective of the application of tape, the AT group showed no difference in hop distance (88 ± 31 cm and 89 ± 30 cm, respectively; $P = 0.56$). This demonstrates that any potential aggravation of symptoms by repeating the hop test was not reflected in a decrease in the ability to hop during the second set. In addition, the healthy group did not show any significant change between first and second sets of hops (129 ± 27 cm and 131 ± 29 cm), indicating no significant order effect ($P = 0.08$).

The VAS scores of the AT group before application of tape ranged widely from 0 to 7.7 cm (1.4 ± 1.6 cm). This level of pain did not change during the hop test with the tape in situ (range, 0-7.1 cm; mean, 1.4 ± 1.7 cm) or after its removal (range, 0-5.6 cm; mean, 1.4 ± 1.4 cm, respectively; $P = 0.74$). The lack of a systematic effect on VAS is shown in Figure 2, which illustrates each participant's results.

The H reflexes of soleus and gastrocnemius were facilitated ($P < 0.001$ and $P < 0.001$, respectively). However, post hoc tests reveal that this facilitation occurred for the healthy participants alone. As illustrated by Figure 3, the amplitude of the soleus and gastrocnemius H reflexes increased after removal of the tape ($P = 0.01$ and $P = 0.03$, respectively). Importantly, this was not the case for the people in the AT group ($P = 0.43$ and $P = 0.16$, respectively). Here, the reflex did not change in amplitude (see Figure 4). Table 1 and Figure 5 show the population data for the details of these differences.

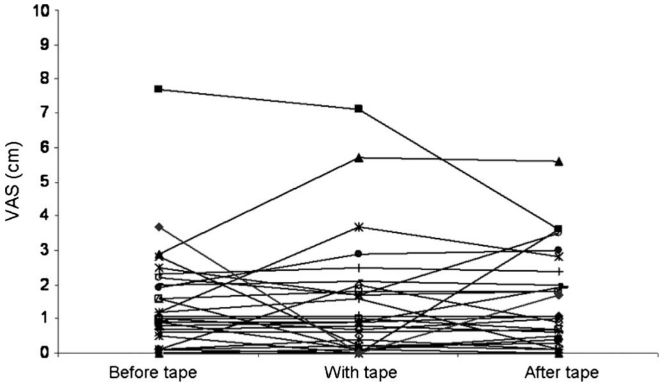

FIGURE 2. The effect of kinesio tape on the VAS for each participant with AT.

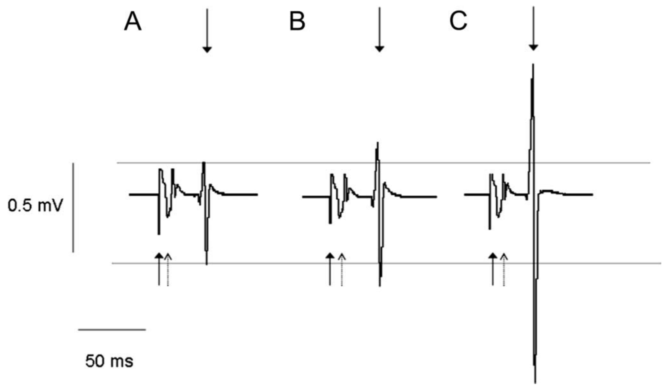

FIGURE 3. Averaged electromyographic activity recorded from the soleus of a healthy subject showing the M response and H reflex evoked by stimulation of the tibial nerve under 3 conditions: without kinesio tape (A), with kinesio tape (B), and after removal of the tape (C). The upward arrow marks the stimulus artifact, the dashed upward arrow marks the M response, and the downward arrow marks the H reflex. Note the consistent amplitude of the M response and the increasing amplitude of the H reflex.

DISCUSSION

This study demonstrates that hop distance does not change with the application of kinesiotape in either healthy people or people with AT. In addition, the tape did not alter either pain or calf muscle motoneuronal excitability in people with AT. However, intriguingly, the motoneuronal pool of

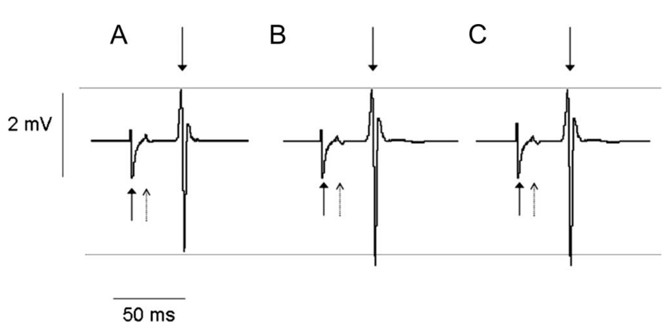

FIGURE 4. Averaged electromyographic activity recorded from the gastrocnemius of an AT subject showing the M response and H reflex evoked by stimulation of the tibial nerve under 3 conditions: without kinesio tape (A), with kinesio tape (B), and after removal of the tape (C). The upward arrow marks the stimulus artifact, the dashed upward arrow marks the M response, and the downward arrow marks the H reflex. Note the consistent amplitude of the M response and the consistent amplitude of the H reflex.

TABLE 1. Hoffman Reflex Amplitudes (mV) for the AT Group and the Healthy Group (Mean ± SD).

	Soleus				Gastrocnemius			
	No Tape	Tape	After Tape	*P*	No Tape	Tape	After Tape	*P*
AT (n = 24)	0.92 ± 1.26	1.07 ± 1.24	1.23 ± 1.36	0.43	1.15 ± 1.78	1.35 ± 1.87	1.49 ± 2.03	0.16
Healthy (n = 24)	1.46 ± 1.28	1.77 ± 1.41	2.00 ± 0.52	0.01	1.17 ± 0.81	1.40 ± 0.83	1.57 ± 0.83	0.03

soleus and gastrocnemius were both facilitated after removal of the tape from healthy people. It is unfortunate that we did not explore the effect of time after removal of the tape to see how long this effect persisted. This finding could be important because many athletes, both amateur and professional, are using this tape with the thought that it might improve performance. However, importantly, it should be noted that any facilitation of the calf muscles was not reflected in any change to hop distance.

This facilitation is in contrast to the previous work that applied rigid tape along the line of fibers of the gastrocnemius muscle; Alexander et al (2008)[18] found that the motoneurone pool of gastrocnemius was inhibited rather than facilitated as seen here. It was speculated that this was due to a change in group I afferent drive. Specifically, tension generated by this more inflexible and thicker tape may have placed the muscle belly in a shortened position, reducing Ia drive from the muscle spindle and consequently reducing the drive to the motoneuronal pool. In this study, the thinner more flexible kinesiotape was not placed over the muscle belly but along the line of the Achilles tendon.[1] It seems unlikely that this thin flexible tape could deform the muscle or indeed the tendon such that there is a change to group I muscle or tendon afferent input to the motoneurone pool. However, other afferent input might drive the facilitatory effect seen here. Cutaneous afferents from the heel and foot evoke a mixed pattern of effects on calf muscle motoneurones[23,24] and can even affect muscles far from the site of stimulation.[25] Indeed, it is interesting to note that removal of the tape, certainly a cutaneous input, increased the facilitation. However, this explanation is pure speculation, especially in the light of the effect being limited to healthy participants alone. Furthermore, there are numerous reflex or descending inputs to a muscle's motoneuronal pool that could drive a change, which cannot be defined using the methods employed in this study. However, whatever the mechanism, there was no functional consequence of the effect.

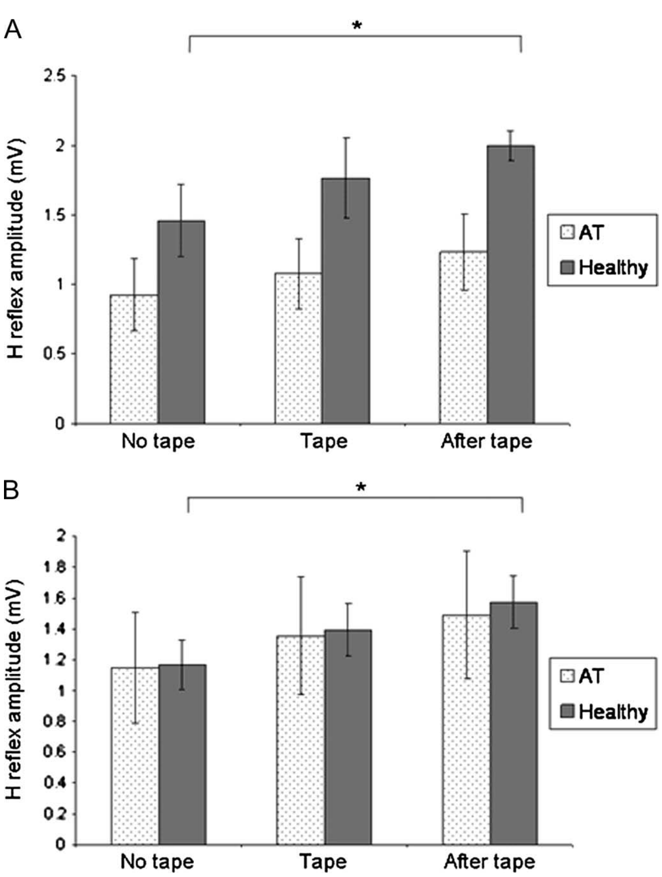

FIGURE 5. A, The mean ± standard error of the mean amplitude of the soleus H reflex under 3 conditions for both the AT (n = 24) group and the healthy group (n = 24). *Significant results ($P < 0.05$). B, The mean ± standard error of the mean amplitude of the gastrocnemius H reflex under 3 conditions for both the AT (n = 24) group and the healthy group (n = 24). *Significant results ($P < 0.05$).

Finally, the pain experienced by the patients with AT was not altered by the application of this tape. Indeed, when the individual results are explored in detail, the pain of 7 participants in the AT group was unaffected and the pain increased in 12 participants and decreased in 10 participants. This suggests a random pattern of events (see Figure 2). As mentioned in the Introduction, Thelen et al (2008)[8] and Gonzalez-Iglesias et al[9] examined people with shoulder pain and acute whiplash disorder to assess the analgesic effect of tape. Our study contrasts with these authors who found a reduction of pain, at least initially, on application of the tape. This was not replicated here. This may be due to the level of pain that these participants were experiencing; it would be interesting to examine the effect of kinesiotape on subgroups of participants experiencing high, moderate, and lower levels of pain.

Limitations

There are some limitations to this study. The healthy group did not match the control group for age or sex. Therefore, although unlikely, there may be age or sex differences in the effect of the tape. Additionally, only immediate effects of tape were observed in this study. As a result of this, any possible longer-term effects of the tape are not known. Moreover, a placebo effect cannot be excluded; it would therefore be beneficial to apply the tape in a sham manner in future studies to control for placebo effects. This would also enable the study to be single-blinded because the subject would be unaware of which taping method is thought to be beneficial.

CONCLUSIONS

The results of this study have shown that there is a facilitation of calf muscle motoneuronal excitability after removal of kinesiotape in healthy participants; however, this was not the case in people with AT. This facilitation did not lead to an increase in hop distance. Additionally, this application of kinesiotape applied for a short period did not affect the level of pain experienced by people with AT. Therefore, the results do not support the use of kinesiotape applied in this way in either healthy or injured people.

Currently, any mechanism of effect of kinesiotape remains unclear. Further research including different methods of application would be of benefit. This would improve the understanding of kinesiotape and its practical use in sport and clinical practice.

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