Journal of Athletic Training 2015;50(8):840–846
doi: 10.4085/1062-6050-50.5.08

www.natajournals.org

original research

Kinesio-Taping Application and Corticospinal Excitability at the Ankle Joint

Francois Tremblay, PhD, PT*†; Siobhan Karam, MHSc, PT*

*School of Rehabilitation Sciences, University of Ottawa, ON, Canada; †Clinical Neuroscience laboratory, Bruyère Research Institute, Ottawa, ON, Canada

Context: Physiotherapists and athletic trainers often use Kinesio Taping (KT) to prevent and treat musculoskeletal injuries in athletes, yet evidence about its effects on neuromuscular performance is conflicting.

Objective: To investigate the influence of a KT application directed at the ankle joint on measures of corticospinal excitability with transcranial magnetic stimulation.

Design: Controlled laboratory study.

Setting: Research laboratory.

Patients or Other Participants: Twelve healthy young women (age = 23.1 ± 1.9 years; range, 19–26 years).

Intervention(s): Participants were tested under no-tape and KT conditions according to a random sequence order. The KT was applied to the skin overlying the dorsiflexor and plantarflexor muscles of the ankle.

Main Outcome Measure(s): We assessed changes in the amplitude of motor-evoked potentials elicited at rest and during movement and changes in the silent period and background muscle activity during movement.

Results: Taping conditions had no effect on motor-evoked potential amplitude at rest or during movement or on the silent-period duration and background muscle activity.

Conclusions: Our results concur with other recent reports, showing KT applications have little influence at the neuromuscular level. Alterations in sensory feedback ascribed to elastic taping are likely insufficient to modulate corticospinal excitability in a functionally meaningful manner.

Key Words: motor cortex, evoked potentials, muscle contraction

Key Points

- Kinesio-Taping applications minimally influenced neuromuscular activity in the lower limbs of healthy participants.
- Taping condition did not affect measures of corticospinal excitability or background electromyography.
- Researchers need to examine whether Kinesio Taping could lead to changes when applied after ankle injuries or for persistent functional ankle instability.
- Sports therapy clinicians should question whether using elastic tape enhances proprioception and muscle performance in healthy athletes.

Kinesio Tape (KT) is used widely by professional and nonprofessional athletes in many sports to improve or restore motor performance. Unlike traditional athletic tape, the cotton material in KT features an acrylic adhesive thought to have a thickness similar to that of the human epidermis and allows a longitudinal stretch of 55% to 60% of its resting length. The air-permeable, water-resistant fabric of KT can be worn for several days in a row.[1] According to the manufacturer, KT's mechanical properties have a variety of beneficial effects on performance, including enhanced kinesthetic awareness, support for muscles and fascia during movement, and correction of joint malalignment. Despite its widespread use and its endorsement by elite athletes, very little evidence is available to support the benefits ascribed to KT applications.[2–4] For instance, in a recent meta-analysis examining the effectiveness of KT in the prevention and treatment of sports injuries, Williams et al[3] identified only a few good-quality studies. Examining the various claims about pain relief, improved range of motion, increased strength, and enhanced proprioception, the authors concluded that the beneficial effects of KT were either inconclusive or trivial in many respects. They did point out studies showing substantial effects of KT applications on muscle activity during motor performance, but it was unclear whether these effects were beneficial or harmful.[3]

In line with observations pointing to some potential effects of KT at the neuromuscular level, researchers have recently examined changes in performance and muscle activation associated with KT applications. Wong et al[5] investigated differences in isokinetic knee function in healthy participants with and without taping applied to the skin overlying the vastus medialis. Whereas torque production was unaffected by taping conditions, the authors reported a reduction in the time to peak torque with KT, which they attributed to motor-unit facilitation arising from cutaneous inputs. However, authors of 2 other subsequent studies addressing the same topic did not find differences in performance or muscle activation between tape and no-tape (NT) conditions.[6,7] At the ankle joint, Firth et al[8] compared performance and motoneuron excitability before and after KT application in healthy participants and participants with Achilles tendinopathy. Performance of single-legged–hop distance did not differ in either group when the tape was applied. Pain level in participants with Achilles tendinopathy was also not influenced by taping conditions. Firth et al[8] observed an increase in soleus (SOL) motoneuron excitability, as reflected by Hoffmann-reflex amplitude immediately after tape removal, but this facilitation was seen only in healthy participants. The authors concluded that KT applications had no real benefit and did not recommend their use for healthy or injured people. Briem et al[9] reached a similar conclusion concerning the potential benefits of KT applications at the ankle joint. They examined neuromuscular responses elicited in ankle muscles during imposed inversion perturbations when standing. Their results showed no difference in neuromuscular responses between the NT and KT conditions.

Given the conflicting evidence regarding their effects on neuromuscular performance, it is difficult to determine whether KT applications are more than a placebo or, as stressed by Vercelli et al,[10] another form of psychological crutch. If a KT application can facilitate neuromuscular performance, notably by enhancing sensory feedback, as claimed by its proponents, then one should be able to detect such effects using sensitive neurophysiologic techniques. In this respect, researchers[11,12] have shown that measures of corticospinal excitability derived from transcranial magnetic stimulation (TMS) are quite sensitive to alteration in sensory feedback induced by sensory stimulation of lower limb afferents. For instance, vibration applied to the patellar tendon can lead to significant facilitation of motor-evoked potentials (MEPs) elicited in thigh muscles at rest.[12] Such MEP facilitation reflects increased excitability at the cortical or spinal level, or both.[13] Similarly, sensory stimulation can lead to changes in the silent period (SP)[14] that is elicited when TMS is delivered during active contractions and that has a duration providing an index of motor cortical inhibition.[13] Thus, both MEP and SP can provide insights into the excitatory and inhibitory processes susceptible to influencing corticospinal excitability when examining modulation in response to peripheral sensory stimulation.

Therefore, the purpose of our study was to investigate the potential neurophysiologic effects of KT applications using TMS to examine modulation of corticospinal excitability. Our goal was to determine whether a KT application aimed at facilitating muscle contraction at the ankle joint could lead to changes in MEPs and in the SP when compared with an NT condition.

METHODS

Participants

A convenience sample of 12 young women (age = 23.1 $\pm$ 1.9 years; range, 19–26 years) was recruited for this study from the population of students in rehabilitation sciences at the University of Ottawa. The sample size was based on the study of Heroux et al[12] and similar TMS investigations[14,15] in which researchers examined modulation of corticospinal excitability in response to sensory stimulation and observed large effect sizes (>0.8 SD). With such an assumption, a sample of 12 participants provided adequate power (80%) for detecting a difference at a bilateral α level of change between conditions equal to or greater than 0.8 SD. We enrolled female participants to avoid concerns related to adherence of the tape when applied over hairy skin areas. Before inclusion, participants were screened for injuries to the lower extremities in the 12 months before the study and for allergy to athletic tape. They were also screened for any contraindication to TMS using a health questionnaire adapted from Keel et al.[15] Participants completed the Ankle Joint Functional Assessment Tool Questionnaire,[16] and volunteers with possible functional ankle instability secondary to ankle injury were excluded.

All participants provided written informed consent, and the study was approved by the Research Ethics Board at the Bruyère Research Institute affiliated with the University of Ottawa.

Procedures

All assessments were performed in a controlled laboratory environment. The experimental design consisted of a within-subject design whereby the 2 conditions, NT and KT, were tested sequentially using a predetermined random order sequence (http://www.randomizer.org; Geoffrey C. Urbaniak and Scott Plous) so that half of the participants were tested first in the NT condition and the other half were tested first in the KT condition. For the KT condition, Kinesio Tex Gold (Kinesio USA Corporation, Albuquerque, NM) elastic sports tape was applied to cover the skin area overlying the ankle dorsiflexors and plantar flexors, targeting their respective origins and insertions. At each site, the same investigator (S.K.) applied 1 strip with approximately 50% tension from the proximal to the distal site using anatomical landmarks to estimate origin to insertion. Such application, according to the KT method, should enhance muscle performance.[17] For 9 participants, the KT was applied to the right ankle, whereas for the remaining 3 participants, the KT was applied to the left because of reports of sprains more than 12 months before the study.

Corticospinal excitability was assessed with participants comfortably seated in a semireclined chair with the hips flexed to approximately 120° and knees fully extended and lying on a footrest. Participants were fitted with a Waveguard TMS-compatible cap (ANT North America Inc, Madison, WI) to allow for consistent coil positioning. The TMS responses were evoked using a Magstim 200 (Magstim Corporation, Whitland, United Kingdom) connected to a double-cone coil (model P/N 9902; Magstim Corporation) with 96-mm loops. Motor-evoked potentials and electromyographic (EMG) activity were recorded using autoadhesive Ag/AgCl surface electrodes (Kendall Medi-Trace 230; Covidien Medical Supplies Inc, Mansfield, MA) with a diameter of 15 mm that were placed over the tibialis anterior (TA) and SOL muscles of the target limb. Electrodes were placed according to SENIAM project (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles) recommendations,[18] with the interelectrode axis aligned with the assumed direction of muscle fibers. To accommodate the strip of tape, we systematically removed a small portion of the electrode adhesive tab with scissors to avoid any overlap, leaving the central recording portion intact. The EMG signals were amplified (model AB-621G bioelectric amplifier; Nihon-Kohden Corp, Irvine, CA) at a 0.03-second time constant and low-pass filtered at 1 kHz, digitized at a rate of 2 kHz (BNC-2090;

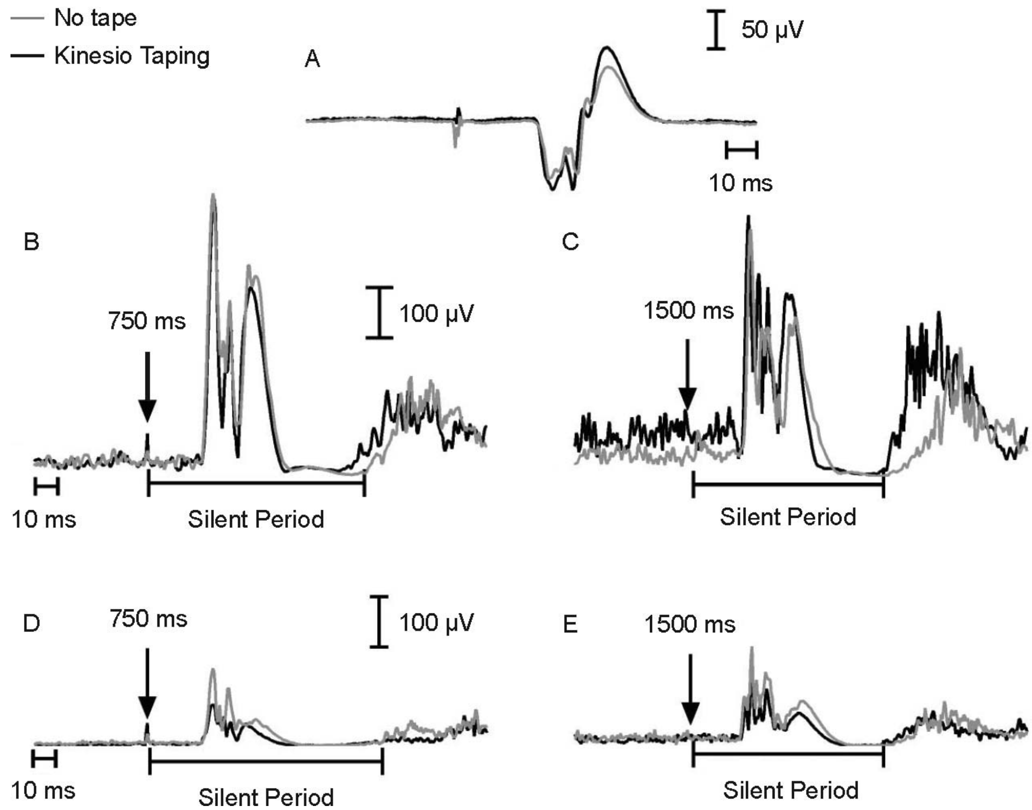

Figure 1. Individual example of variations in motor-evoked potentials (MEPs) recorded in the tibialis anterior muscle under the no-tape and Kinesio-Tape conditions. A, Unrectified MEPs traces measured at rest. B–D, Rectified MEP traces elicited at the 2 times used for transcranial magnetic stimulation during active dorsiflexion (B and C) and active plantar flexion (D and E). For each movement direction and each time, the approximate duration of the silent period is also shown as the time interval from stimulation until recovery of muscle activity. Note that taping condition had only minimal influence on MEP amplitude either at rest or during movement.

National Instrument Corp, Austin, TX), and relayed to a laboratory computer running custom software to control acquisition.

Before testing, the resting motor threshold (rMT) was determined using the Motor Threshold Assessment Tool software (MTAT 2.0; ClinicalResearcher, Knoxville, TN).[19] The software allows for fast estimation of motor threshold through the maximum-likelihood strategy based on the parameter estimation by sequential testing algorithm.[20] This method yielded rMTs (44.8% $\pm$ 6.2% maximal stimulator output) comparable with those reported in other TMS studies using other methods.[21] All subsequent responses to TMS were evoked using an intensity fixed at 110% rMT.

We always tested corticospinal excitability first at rest and second during active movement. For measures at rest, TMS responses ($n = 10$) were elicited while we monitored EMG activity on a high-gain oscilloscope to ensure relaxation was maintained. For measures in the active state, participants were trained to move the ankle into either dorsiflexion (DF) or plantar flexion (PF) in response to an auditory tone lasting 1.5 seconds. Their instructions were to synchronize the execution with the duration of the tone so that movement proceeded from full PF to maximal DF for DF movements and in the reverse direction for the PF movements. We chose this movement duration because the speed was comfortable and easily reproducible while allowing stable recording conditions by minimizing the risk of movement artifacts. During movement, TMS was delivered at 2 different times corresponding to midrange (750 milliseconds) and end range (1500 milliseconds). The 2 times in a given direction were presented using a predetermined random sequence of 20 trials (ie, 10 MEPs per delay). The order of testing with DF and PF movements was counterbalanced across participants.

After completing TMS testing, participants performed a series of 3 static contractions against resistance in each direction (DF and PF) with no tape. For this test, participants remained seated with the ankle in neutral position (90°). Their instructions were to push in an attempt to break the resistance (ie, break test) provided by the examiner (F.T.) for the duration of a 3-second auditory tone. The same investigator, who was a male registered physical therapist, always provided the resistance using positions recommended for handheld dynamometry testing procedures.[22] These contractions, especially in the case of PF, were not necessarily maximal but still provided a steady level of near-maximal activation, which could be used as a reference to compare muscle activity produced during ankle movements tested with TMS.

Data Analysis

All MEP data were analyzed off-line. First MEP traces were overlaid and then averaged to derive individual mean (peak-to-peak) amplitudes for each muscle, movement direction, and time for the NT and KT conditions. In trials with movement, the duration of the SP was also measured. To avoid error in defining the onset of the EMG silence and

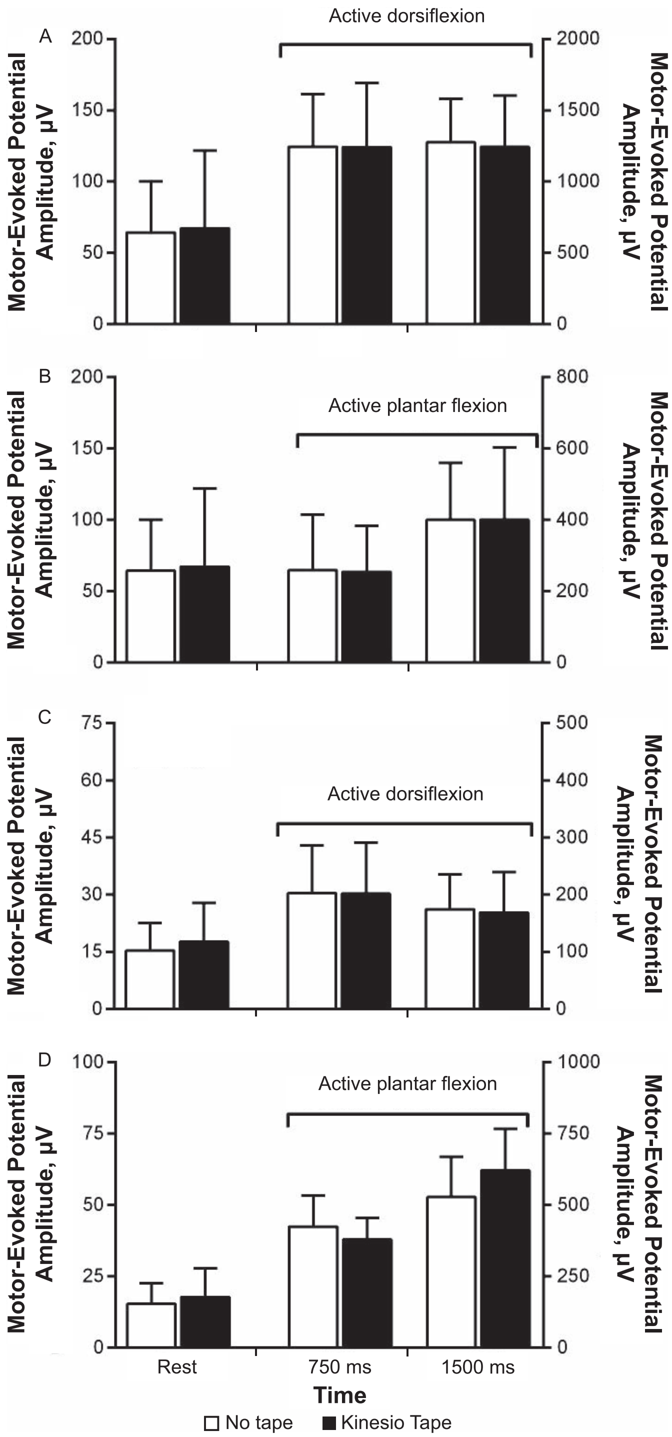

Figure 2. Mean amplitude of motor-evoked potentials (MEPs) computed for the no-tape and Kinesio-Tape conditions in the A and B, tibialis anterior, and C and D, soleus muscles. The MEP amplitude computed at rest is shown relative to the left y-axis, whereas the MEP amplitude computed during dorsiflexion and plantar-flexion movement at the 2 times is shown relative to the right y-axis. Note the minimal influence of taping conditions on MEPs both at rest and during movement.

as suggested by Säisänen et al,[23] the duration was identified as the time interval from the TMS pulse until the first sign of sustained (>10 milliseconds) recovery in EMG activity. Finally, to assess the effect of taping condition on background activity, the EMG activity produced in the TA and SOL during DF and PF was rectified and then averaged over the 100-millisecond period preceding the TMS pulses at each time (750 and 1500 milliseconds). This activity was expressed as a percentage of the average EMG produced during the reference static contractions (2000–3000-millisecond averaging window).

Statistical Analysis

The statistical analysis was carried out in 3 steps. First, a paired *t* test was used to determine the effect of taping condition on MEP amplitude measured at rest. Second, variations in MEP amplitude measured in the TA and SOL during active movement were entered into a 2 × 2 × 2 repeated-measures analysis of variance (ANOVA) to determine the effect of taping condition (NT, KT), movement direction (DF, PF), and time (750 milliseconds, 1500 milliseconds). The same analysis was performed for variations in SP duration. Third, a 2 × 2 ANOVA was carried out to determine the effect of taping condition (NT, KT) and time (750 milliseconds, 1500 milliseconds) on background EMG levels produced in the TA and SOL while they acted as agonist muscles to move the ankle in either DF or PF. The α level was set at .05 for all tests. All results are reported as means ± standard deviations. Statistical analysis was performed with IBM SPSS Statistics for Windows (version 21.0; IBM Corporation, Armonk, NY).

RESULTS

All participants exhibited a score equal to or greater than the recommended cutoff (ie, 26/48) on the Ankle Joint Functional Assessment Tool Questionnaire (mean score = 43.8 ± 8.3), so no participant was excluded based on functional ankle instability. As noted, the KT was applied to the left ankle in 3 participants to avoid potential confounding related to past injury in the right ankle (>12 months), but their Ankle Joint Functional Assessment Tool Questionnaire scores indicated no chronic instability. All participants completed the protocol without concerns or discomfort.

In general, only small variations in MEP amplitude were observed in the TA and SOL for taping conditions. A typical example of such variations is shown in Figure 1 for the TA muscle. The MEPs measured at rest were very similar under the NT and KT conditions. Similarly, MEPs measured during active movement showed comparable modulation between taping conditions, but the large effect of movement direction is clearly apparent, as MEPs in TA tended to be larger during DF than PF movements.

The overall mean MEP amplitude computed at rest and during movement is shown in Figure 2. Taping condition had no systematic influence on MEP amplitude measured at rest for the TA ($t_{11} = 0.43$, $P = .67$) or SOL ($t_{11} = 1.58$, $P = .14$). We observed the same for MEP amplitude elicited during movement, with taping condition accounting for only a negligible proportion of the variance ($F_{1,11}$ range, 0.01–0.09; $P > .70$). The major influence of movement direction was confirmed, with this factor alone accounting for more than 40% of the variance in MEP amplitude during movement for the TA ($F_{1,11} = 87.1$, $P < .001$) and SOL ($F_{1,11} = 7.0$, $P = .02$). This directional effect reflected the larger-amplitude facilitation elicited in parallel with

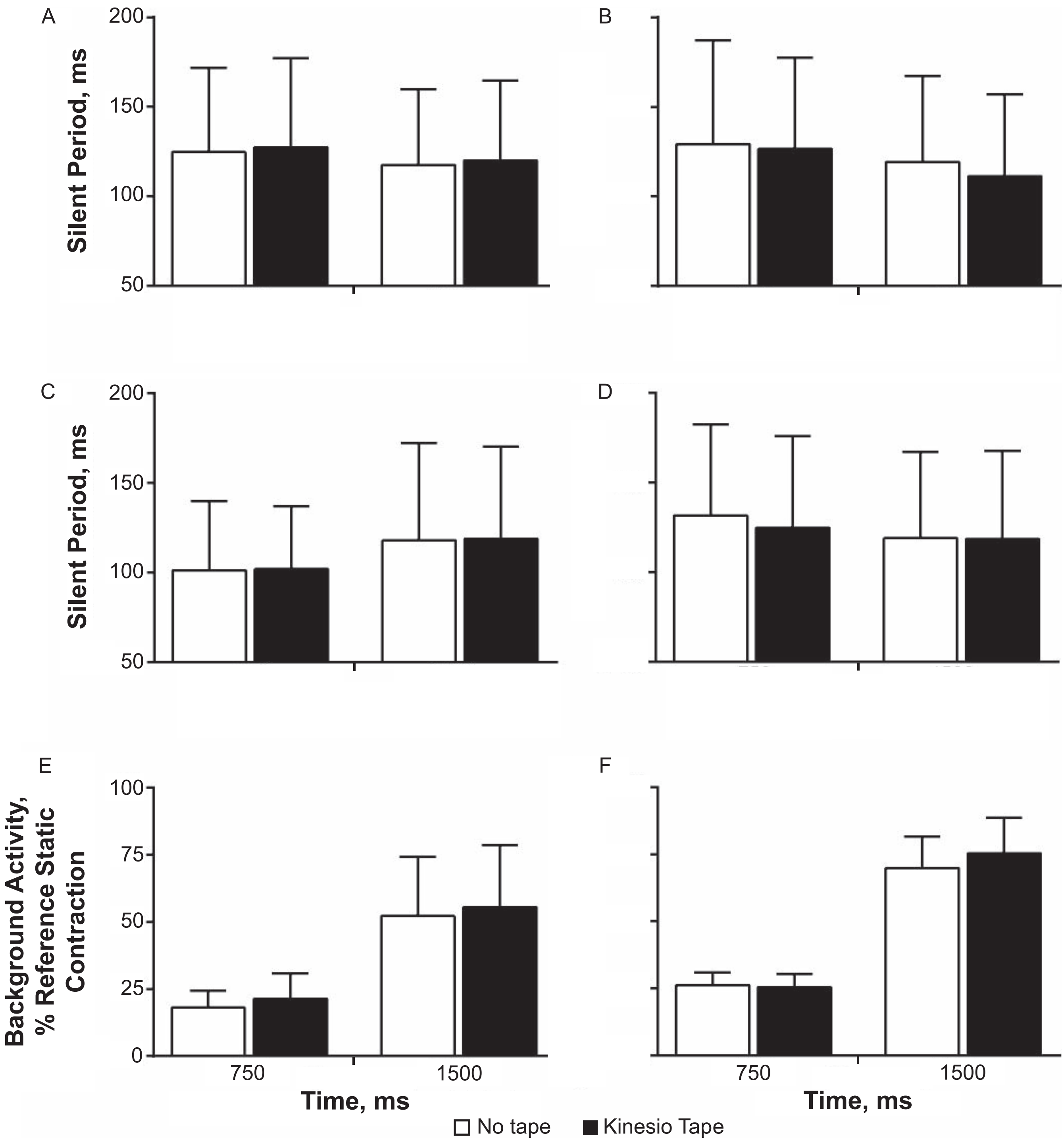

Figure 3. Mean variations measured in the silent period and background muscle activity under the no-tape and Kinesio-Tape conditions. A–D, Variations in the silent period at the 2 time points are shown for the tibialis anterior (TA) muscle for A, dorsiflexion, and B, plantar flexion, and the soleus (SOL) muscle for C, dorsiflexion, and D, plantar flexion. E–F, Variations in background muscle activity are given for both the TA and SOL as percentages of the reference static contraction when they were acting as agonist muscles to move the ankle into E, dorsiflexion (TA), or F, plantar flexion (SOL). Note that taping conditions had little influence on the silent period or muscle activity.

increased EMG activity when the muscle was acting as an agonist rather than an antagonist (ie, DF for TA and PF for SOL). We did not observe a main effect of time for the TA ($F_{1,11} = 3.4$, $P = .09$) or SOL ($F_{1,11} = 2.7$, $P = .16$).

As shown in Figure 3A through D, variations in SP duration measured during movement were largely unaffected by taping condition. The ANOVA for TA revealed a main effect only for time ($F_{1,11} = 9.9$, $P = .009$); the SP duration tended to be shorter at 1500 than at 750 milliseconds irrespective of taping condition or movement direction ($F_{1,11}$ range, 0.15–0.46; $P > .70$). In the SOL, no main effect ($F_{1,11}$ range, 0.26–2.50; $P > .15$) or interaction ($F_{1,11}$ range, 0.44–3.10; $P > .10$) was detected.

Much like the other variables, the taping conditions had no effect ($F_{1,11}$ range, 0.23–1.51; $P > .20$) on background EMG activity generated in the TA and SOL during DF and

PF movements (Figure 3E and F). In fact, much of the variability in background EMG activity was explained by the time factor (Figure 3E and F), which accounted for more than 75% of the variance in the TA and SOL ($F_{1,11}$ range, 34.6–49.7; $P < .001$).

DISCUSSION

In line with recent investigations,[6,7,24] we did not find any effects of a KT application at the ankle joint on corticospinal excitability. Our measures of excitability, including MEP amplitude and SP duration, were largely unaffected by taping condition. In addition, we found no effect when comparing background EMG levels in ankle muscles during movement under the NT and KT conditions.

Given neurophysiologic evidence that sensory-afferent stimulation has profound and diffuse influences over the leg motor cortex in the resting state,[11] we were surprised to find that MEPs at rest were unchanged even after a substantial portion of the lower leg was covered with elastic tape. It seems likely that, in the absence of movement, the KT application was not sufficient to lead to a change in afferent feedback from the leg. Motor-evoked potential modulation reported in TMS studies is usually observed in response to controlled electrical stimulation, which cannot be compared with the sensory stimulation arising from tape application. In addition, MEPs evoked in the near-neutral position could have been another factor, because passive stretch is known to influence measures of neural excitability at the ankle joint.[25,26] For instance, Guissard et al[27] showed that small-amplitude stretches effectively depressed motoneuron excitability as reflected in the Hoffmann reflex, whereas stretches of larger amplitude were required to modulate cortically induced MEPs. Thus, both ankle positioning and the lack of proper skin afferent stimulation might explain why MEPs in the resting state were unaffected by KT.

The lack of strong afferent stimulation may explain the absence of modulation at rest, but this explanation could not be applied for MEPs elicited during movement, when alteration in sensory feedback resulting from KT was likely most potent. In this condition, MEP facilitation was largely a function of movement direction in parallel with TA and SOL activation, regardless of taping condition. Voluntary activation promptly leads to MEP facilitation via increased excitability at the cortical level coupled with a lowering of activation thresholds at the spinal level through afferent feedback to motoneurons.[13] Therefore, saturation might have prevented the detection of extra facilitation associated with the KT condition. However, this is very unlikely given that MEPs were elicited with a low intensity of stimulation (110% rMT) and at a relatively low level of effort. In fact, the intensity of contraction is less of a concern in the leg motor representation because facilitation can be elicited over a wide range of effort.[28] Still, given the sensitivity of MEPs to sensory modulation, we are puzzled that no change was detected with the ankle taped. In this regard, our results are not much different from those of Lins et al[6] and Briem et al,[9] who did not detect changes in voluntary muscle activity in the quadriceps muscle when comparing NT and KT conditions. In our study, taping condition also did not affect background activity generated in the TA and SOL during movement or SP duration. As stated, the SP provides an index of cortical inhibition, and variations in TMS intensity and contraction levels affect its duration.[13] Given that TMS intensity was kept constant in our study, it is likely that variations in EMG levels between the NT and KT conditions were simply too small, as confirmed by our analysis of background EMG activity, to alter inhibition at the cortical level and elicit changes in SP.

LIMITATIONS AND CONCLUSIONS

Our results concur with those of recent studies showing that KT applications have only minimal influence on neuromuscular activity in the lower limb. Our measures of both corticospinal excitability (MEPs and SP) and background EMG activity during active ankle movements were largely unaffected by taping condition. Yet our conclusion is limited because our observations were derived from healthy participants with no recent injuries to the ankle joint. It remains to be seen whether KT could lead to greater change when applied in the context of ankle rehabilitation after injuries or in patients with persisting functional ankle instability. Given our results and other recent evidence, clinicians working in sports therapy should question the utility of using elastic tape to enhance proprioception and muscle performance in healthy athletes.

REFERENCES

1. Kase K, Wallis J, Kase T. *Clinical Therapeutic Applications of the Kinesio Taping Method*. Tokyo, Japan: Ken Ikai Co Ltd; 2003.
2. Morris D, Jones D, Ryan H, Ryan CG. The clinical effects of Kinesio Tex taping: a systematic review. *Physiother Theory Pract*. 2013; 29(4):259–270.
3. Williams S, Whatman C, Hume PA, Sheerin K. Kinesio taping in treatment and prevention of sports injuries: a meta-analysis of the evidence for its effectiveness. *Sports Med*. 2012;42(2):153–164.
4. Mostafavifar M, Wertz J, Borchers J. A systematic review of the effectiveness of Kinesio taping for musculoskeletal injury. *Phys Sportsmed*. 2012;40(4):33–40.
5. Wong OM, Cheung RT, Li RC. Isokinetic knee function in healthy subjects with and without Kinesio taping. *Phys Ther Sport*. 2012; 13(4):255–258.
6. Lins CA, Neto FL, Amorim AB, Macedo Lde B, Brasileiro JS. Kinesio Taping does not alter neuromuscular performance of femoral quadriceps or lower limb function in healthy subjects: randomized, blind, controlled, clinical trial. *Man Ther*. 2013;18(1):41–45.
7. Vercelli S, Sartorio F, Foti C, et al. Immediate effects of kinesiotaping on quadriceps muscle strength: a single-blind, placebo-controlled crossover trial. *Clin J Sport Med*. 2012;22(4): 319–326.
8. Firth BL, Dingley P, Davies ER, Lewis JS, Alexander CM. The effect of kinesiotape on function, pain, and motoneuronal excitability in healthy people and people with Achilles tendinopathy. *Clin J Sport Med*. 2010;20(6):416–421.
9. Briem K, Eythörsdöttir H, Magnúsdóttir RG, Pálmarsson R, Rúnarsdottir T, Sveinsson T. Effects of Kinesio Tape compared with nonelastic sports tape and the untaped ankle during a sudden inversion perturbation in male athletes. *J Orthop Sports Phys Ther*. 2011;41(5):328–335.
10. Vercelli S, Ferriero G, Bravini E, Sartorio F. How much is Kinesio taping a psychological crutch? *Man Ther*. 2013;18(3):e11.
11. Roy FD, Gorassini MA. Peripheral sensory activation of cortical circuits in the leg motor cortex of man. *J Physiol*. 2008;586(pt 17): 4091–4105.
12. Heroux M, Tremblay F, Tremblay LE, Boisvenue M, Carriere M, Houston J. Differential effect of peripheral electrical stimulation and

vibratory stimulation on corticomotor excitability in lower limb muscles. *Physiother Can*. 2003;55(3):153–157.
13. Abbruzzese G, Trompetto C. Clinical and research methods for evaluating cortical excitability. *J Clin Neurophysiol*. 2002;19(4): 307–321.
14. Binder C, Kaya AE, Liepert J. Vibration prolongs the cortical silent period in an antagonistic muscle. *Muscle Nerve*. 2009;39(6):776–780.
15. Keel JC, Smith MJ, Wassermann EM. A safety screening questionnaire for transcranial magnetic stimulation. *Clin Neurophysiol*. 2001;112(4):720.
16. Rozzi SL, Lephart SM, Sterner R, Kuligowski L. Balance training for persons with functionally unstable ankles. *J Orthop Sports Phys Ther*. 1999;29(8):478–486.
17. Kinesio taping method. Kinesio Taping Association International Web site. http://www.kinesiotaping.com/about/kinesio-taping-method. Accessed January 13, 2015.
18. Hermens HJ, Freriks B, Disselhorst-Klug C, Rau G. Development of recommendations for SEMG sensors and sensor placement procedures. *J Electromyogr Kinesiol*. 2000;10(5):361–374.
19. Borckardt JJ, Nahas Z, Koola J, George MS. Estimating resting motor thresholds in transcranial magnetic stimulation research and practice: a computer simulation evaluation of best methods. *J ECT*. 2006;22(3):169–175.
20. Mishory A, Molnar C, Koola J, et al. The maximum-likelihood strategy for determining transcranial magnetic stimulation motor threshold, using parameter estimation by sequential testing is faster than conventional methods with similar precision. *J ECT*. 2004; 20(3):160–165.
21. Brouwer B, Qiao J. Characteristics and variability of lower limb motoneuron responses to transcranial magnetic stimulation. *Electroencephalogr Clin Neurophysiol*. 1995;97(1):49–54.
22. Amundsen LR. *Muscle Strength Testing: Instrumented and Non-Instrumented Systems*. New York, NY: Churchill Livingstone; 1990.
23. Säisänen L, Pirinen E, Teitti S, et al. Factors influencing cortical silent period: optimized stimulus location, intensity and muscle contraction. *J Neurosci Methods*. 2008;169(1):231–238.
24. de Hoyo M, Alvarez-Mesa A, Sanudo B, Carrasco L, Dominguez S. Immediate effect of Kinesio taping on muscle response in young elite soccer players. *J Sport Rehabil*. 2013;22(1):53–58.
25. Brooke JD, McIlroy WE, Miklic M, et al. Modulation of H reflexes in human tibialis anterior muscle with passive movement. *Brain Res*. 1997;766(1–2):236–239.
26. Robinson KL, McComas AJ, Belanger AY. Control of soleus motoneuron excitability during muscle stretch in man. *J Neurol Neurosurg Psychiatry*. 1982;45(8):699–704.
27. Guissard N, Duchateau J, Hainaut K. Mechanisms of decreased motoneurone excitation during passive muscle stretching. *Exp Brain Res*. 2001;137(2):163–169.
28. Oya T, Hoffman BW, Cresswell AG. Corticospinal-evoked responses in lower limb muscles during voluntary contractions at varying strengths. *J Appl Physiol*. 2008;105(5):1527–1532.

Address correspondence to Francois Tremblay, PhD, PT, School of Rehabilitation Sciences, University of Ottawa, 451 Smyth, Ottawa, ON K1H8M5, Canada. Address e-mail to francois.tremblay@uottawa.ca.