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Research article

Kinesio Taping in Young Healthy Subjects Does Not Affect Postural Reflex Reactions and Anticipatory Postural Adjustments of the Trunk: A Pilot Study

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Abstract

Therapeutic Kinesio Taping method is used for treatment of various musculo-skeletal conditions. Kinesio Taping might have some small clinically important beneficial effects on range of motion and strength but findings about the effects on proprioception and muscle activation are inconsistent. The aim of this study was to test if Kinesio Taping influences anticipatory postural adjustments and postural reflex reactions. To test the hypothesis twelve healthy young participants were recruited in randomized, participants blinded, placebo controlled cross -over study. In the experimental condition the tape was applied over the paravertebral muscles and in placebo condition sham application of the tape was done transversally over the lumbar region. Timing of anticipatory postural adjustments to fast voluntary arms movement and postural reflex reactions to sudden loading over the hands were measured by means of superficial electromyography before and one hour after each tape application. Results showed no significant differences between Kinesio Taping and placebo taping conditions for any of the analyzed muscles in anticipatory postural adaptations ($F_{1,11} < 0.23$, $p > 0.64$, $\eta^2 < 0.04$) or postural reflex reactions ($F_{1,11} < 4.16$, $p > 0.07$, $\eta^2 < 0.49$). Anticipatory postural adjustments of erector spinae and multifidus muscles were initiated significantly earlier after application of taping (regardless of technique) compared to pre-taping ($F_{1,11} = 5.02$, $p = 0.046$, $\eta^2 = 0.31$ and $F_{1,11} = 6.18$, $p = 0.030$, $\eta^2 = 0.36$ for erector spinae and multifidus, respectively). Taping application over lumbar region has potential beneficial effects on timing of anticipatory postural adjustments regardless of application technique but no effect on postural reflex reactions in young pain free participants. Further research in patients with low back pain would be encouraged.

Key words: Low back pain, Postural balance, Physical therapy technique, Mechanoreceptors.

Introduction

Therapeutic Kinesio Taping (KT) method is used for treatment of various musculo-skeletal conditions. The tape has been designed to allow for a longitudinal stretch of 55 – 60% of its resting length. This mimics the qualities of the skin and after approximately 10 minutes the client will generally not perceive there is a tape on his/her skin (Kase et al., 2003). The method was first introduced by Kenzo Kase to mechanically support the movement and to enhance sensory input to mechanoreceptors. In a recent meta-analysis about effects of KT in treatment and prevention of sport injuries, Williams and colleagues (2012) included both studies on patients and on healthy population. They concluded that KT might have some small clinically important beneficial effects on range of motion and strength but most likely only trivial effects on pain perception. Similar conclusion were made in systematic review by Kalron and Bar- Sela (2013) who noted that the effects are probably only immediate since no long term effects are reported. The mechanisms by which KT would achieve expected results have not been fully elucidated.

Effects of KT on proprioception and muscle activation are inconsistent. According to the founder of the KT the tape can be applied in two conceptually different ways as regards to the direction of the application and the amount of the stretch of the tape during application. This way, KT is thought to facilitate or inhibit muscle function via cutaneous stimulation. To inhibit muscle function the tape should be applied with very light (15 to 25 % of the available) tension in the direction from insertion to origin and to facilitate muscle function the tape is applied in the opposite direction with moderate (25 – 50 % of the available) tension (Kase et al., 2003). KT have shown positive effects on force sense in healthy population (Chang et al., 2010), in subjects with medial epicondylitis (Chang et al., 2012) and in subjects with a functionally unstable ankle (Simon et al., 2013). On the other hand, no significant effects of KT have been shown on joint position sense of the ankle (Halseth et al., 2004) or elbow (Fratocchi et al., 2013). It has been suggested that KT has more influence on skin and muscle mechanoreceptors and less on joint receptors (Chang et al., 2010). This could also result in facilitation that has been shown immediately after application of KT as an increase in muscle activation of the gastrocnemius muscle during vertical jumping (Huang et al., 2011) and an increase in muscle activity of the lower trapezius during shoulder abduction (Hsu et al., 2009). On the contrary, Briem and colleagues (2011) reported no influence on fibularis longus muscle activation during inversion perturbation and Lins and colleagues (Lins et al., 2013) found no influence on vastus lateralis activation during concentric and eccentric leg extension in isokinetic conditions. Studies were mostly investigating effects of KT on limb movements but there is a lack of data on trunk musculature.

Both proprioception and muscle activation have important roles in maintaining spinal equilibrium especially in the presence of disturbances (Hodges et al., 2009). In predictable perturbations (i.e. from quick voluntary movement of limbs) the central nervous system induces anticipatory postural adjustments (APA) in a feedforward manner, based on afferent input and previous

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experiences. When a mechanical perturbation is unexpected it elicits reflex activation of postural muscles (i.e. postural reflex responses (PRRs)). Both mechanisms of neuromuscular control of spinal stability are most often assessed using superficial electromyography (EMG) and have been extensively studied in the context of low back pain (Radebold et al., 2001, Hodges, 2001, Reeves et al., 2005). Although biomechanical etiology of low back pain is not precisely known it seems that small neuromuscular errors are amplified by biomechanical forces causing sudden undesired vertebral motion (Granata et al., 2004). Inappropriate proprioception has been a suggested reason for changes in timing of trunk muscle activation (Radebold et al., 2001).

It has been previously shown that light sensory input can modify motor output (Aimonetti et al., 2000; Rosenkranz and Rothwell, 2012). Paoloni and colleagues (2011) also found that the application of KT over trunk extensor muscles can help restore normal levels of extensor muscles activation in full trunk flexion in patients with low back pain. To our knowledge, no research of KT on automatic stabilizing functions of the trunk muscles has been done. Therefore the aim of this pilot study was to investigate if application of KT applied over trunk extensor muscles influence trunk APAs and PRRs in young healthy population. Further, a potential difference between the recommended KT application and placebo taping (PT) was investigated.

Methods

Participants

In the present study 12 active college students were recruited (4 female and 8 male, [Mean ± Standard Deviation] 23.4 ± 3.5 years, 1.81 ± 0.09 m and 74.8 ± 13.1 kg). Participants were healthy individuals and had no low back pain in last 6 months. Participants had no history of low back problems that would require sick leave or limit function for more than three days. They also had no known neurological disorders or sensory deficits. After explaining the purpose and potential risks of the study, a written informed consent was obtained. The study was conducted in accordance with the Helsinki declaration and was approved by the National Medical Ethics Committee.

Intervention and testing procedures

Measurements were performed in a randomized, placebo controlled cross-over study design. The participants underwent two study conditions, namely KT and PL. They were randomly assigned into KT or PT group in a counterbalanced order. Randomization has been carried out with a custom-written algorithm in LabVIEW (National Instruments, Austin, Texas, USA). The participants were blinded of KT or PT condition and they all participated in both conditions. The measurement sequence was identical for all the participants on both visits. First, in case of both conditions (i.e. tape applications) the participant was tested without tape application (NT). Second, the tape was applied to the lower back area (for details see below). Finally, 60 min after the tape application, the post-measurements were carried out.

In the KT condition three “I” stripes of elastic tape (Darco International, Inc., Huntington, USA) were placed in parallel with the goal of muscle facilitation. One stripe was placed from the line between left and right posterior superior iliac spine to procesus spinosus of 12th thoracic vertebrae (Paoloni et al., 2011). This distance was first measured and then reduced by 25 % to determine the resting length of the tape and consequently get near to 50 % of the available 50 - 60 % stretch of the tape when applied. On both ends 3 to 5 cm of the “I” stripe was applied without tension. The other two stripes were placed 4 cm laterally from the first stripe with the same length and tension (Paoloni et al., 2011). In PT condition a single 20 cm “I” stripe with no tension was placed transversely at level of 2nd lumbar vertebrae (Figure 1) (Paoloni et al., 2011). Participants were naive about the KT method and it was explained that they are receiving two types of therapeutic taping applications. All taping was applied by a single investigator trained in KT method. The taping was applied for 60 min and during this time the subjects were controlled for their physical activity (standing, easy walking).

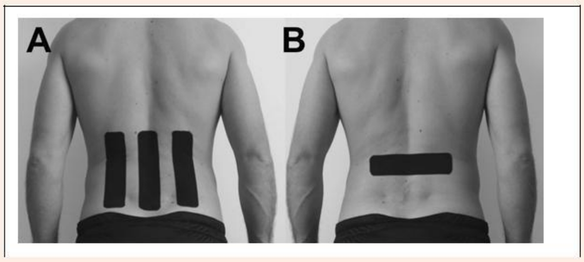

Figure 1. Kinesio tape placement in experimental (A) and placebo (B) condition.

Electrical activity of 5 trunk muscles (Figure 2) was measured with surface electromyography (EMG). Skin was first shaved and disinfected. Reusable electrodes with fixed 1 cm center-to-center distance (S2P Ltd., Ljubljana, Slovenia) and conductive cream (Ten20 conductive, Weaver and company, Denver, Colorado, USA) were used. EMG signals of multifidus at level L5 (MF), erector spine at level L1 (ES), rectus abdominis (RA), obliquus externus (OE), and obliquus internus (OI) were recorded on the right side of the body with electrodes placed in accordance with previous studies (Hibbs et al., 2011; Radebold et al., 2000; Stokes et al., 2006). A reference electrode was placed over the right great trochanter.

Measurements of APAs prior to fast arm raise and PRRs to sudden loading were performed in each condition. Each test consisted of 20 trials (2 sets x 10 repetitions with 1 min breaks between sets) (Voglar and Sarabon, 2014). The tests were performed in random order with a 2 min break between the tests. The participant was barefooted and asked to place the feet at the hip-width (we marked the position for repositioning between sets). They were constantly reminded to maintain their normal posture and to stand relaxed.

In APAs test the task was to raise a 0.3 kg bar, as fast as possible, shoulder high on a self-selected timing after an audio cue (Figure 2-A). APAs onset times were calculated as the difference between the activation onset of the deltoideus muscle and the activation onset of each trunk muscle. Activation onset detection was limited on a time window from 150 ms before to 100 ms after the beginning of the prime mover`s (deltoideus anterior) activation. In measurements of PRRs to sudden loading participants stood relaxed, with their elbows 90° flexed and palms slightly touching the weight handle (Figure 2-B). After the load release, the participant's task was, to return and settle into the initial position, as quickly as possible. The load was 7% to 10% of the participant`s body mass. For the purpose of sudden loading, a custom made, electromagnet based, quick release mechanism was used. PRRs onset times were calculated as a delay from mechanism release to trunk muscle activation. In PRRs measurements activation onset detection was limited to the time window from the moment of mechanism release to 150 ms after.

Data analysis

The signals were 3,000x amplified (S2P Ltd., Ljubljana, Slovenia), and sampled at 10,000 Hz. Raw EMG signals were analog-to-digital converted (USB-6343, NI, Austin, Texas, USA), visually inspected for noise detection in real time and stored on a personal computer for later analysis. Signals were zero aligned and band-pass filtered (zero lag Butterworth filter 10 Hz/1kHz, order 2). Approximated generalized likelihood-ratio step algorithm (Staude and Wolf, 1999) for automatic detection (Labview, NI, Texas, USA) was used to determine the beginning of muscle activity (settings: threshold - 50%, baseline window - 500ms, search window - 25ms and dead zone - 100ms). All signals were later manually inspected and corrected when activation was obviously false detected by the com-puter algorithm due to artifacts or removed from analysis when there was no activation within detection limits.

SPSS 18.0 (SPSS Inc., Chicago, USA) was used for statistical analyses. Descriptive statistics were calcu-lated for all variables and reported as mean (± standard errors). Kolmogorov – Smirnov test showed normal dis-tribution of the data. Two way repeated measures ANO-VAs were used with repeated measures on condition (PT and KT) and on time (pre application and post applica-tion) for each muscle in both tests. For all the analyses the level of statistical significance was set at $p < 0.05$ and η^2 effect size estimation is presented.

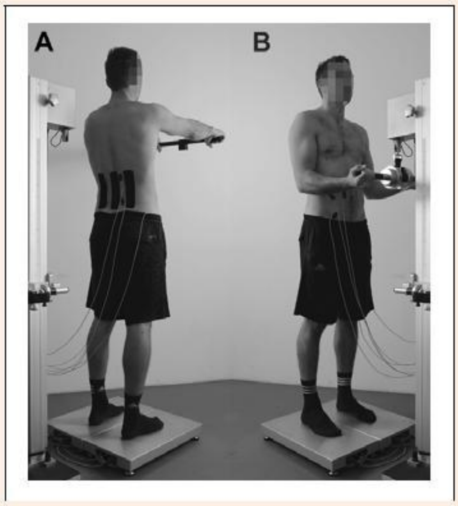

Figure 2. Measurements of anticipatory postural adaptations (A), were assessed with fast bilateral shoulder flexion on self-selected timing after audio cue. In measurements of postural reflex responses to sudden loading (B) electro-magnet based quick release system was used to release load (4 kg for fe-male and 7 kg for male participants) over the subject`s hands. Note the placement of the EMG electrodes.

Results

All recruited participants (n = 12) completed the study (Figure 3). For both the KT and PT condition there was no significant difference in baseline measurements (Fig-ure 4).

After taping application, measurements of APAs showed statistically significantly earlier activation of back

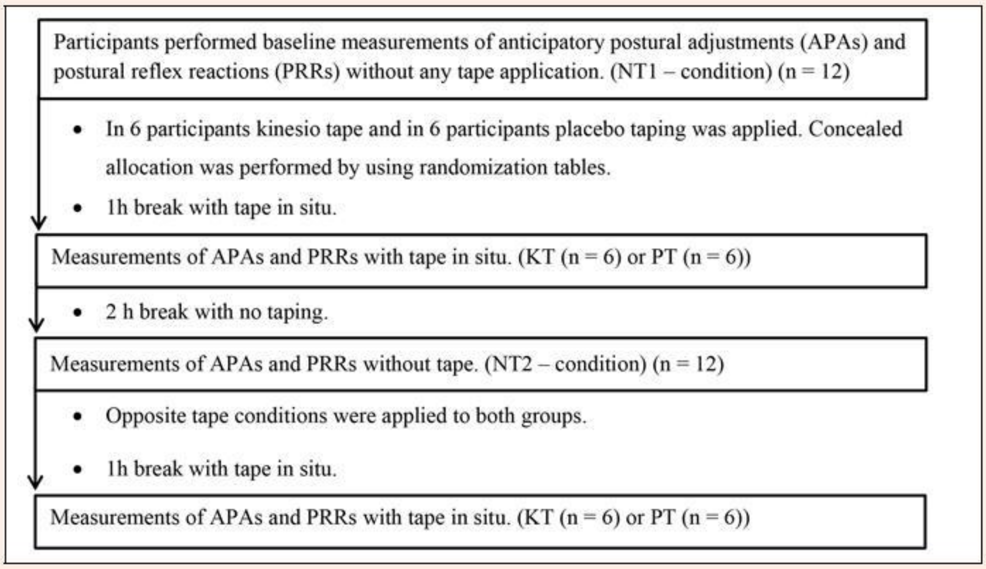

Figure 3. Study design and time flow of the study.

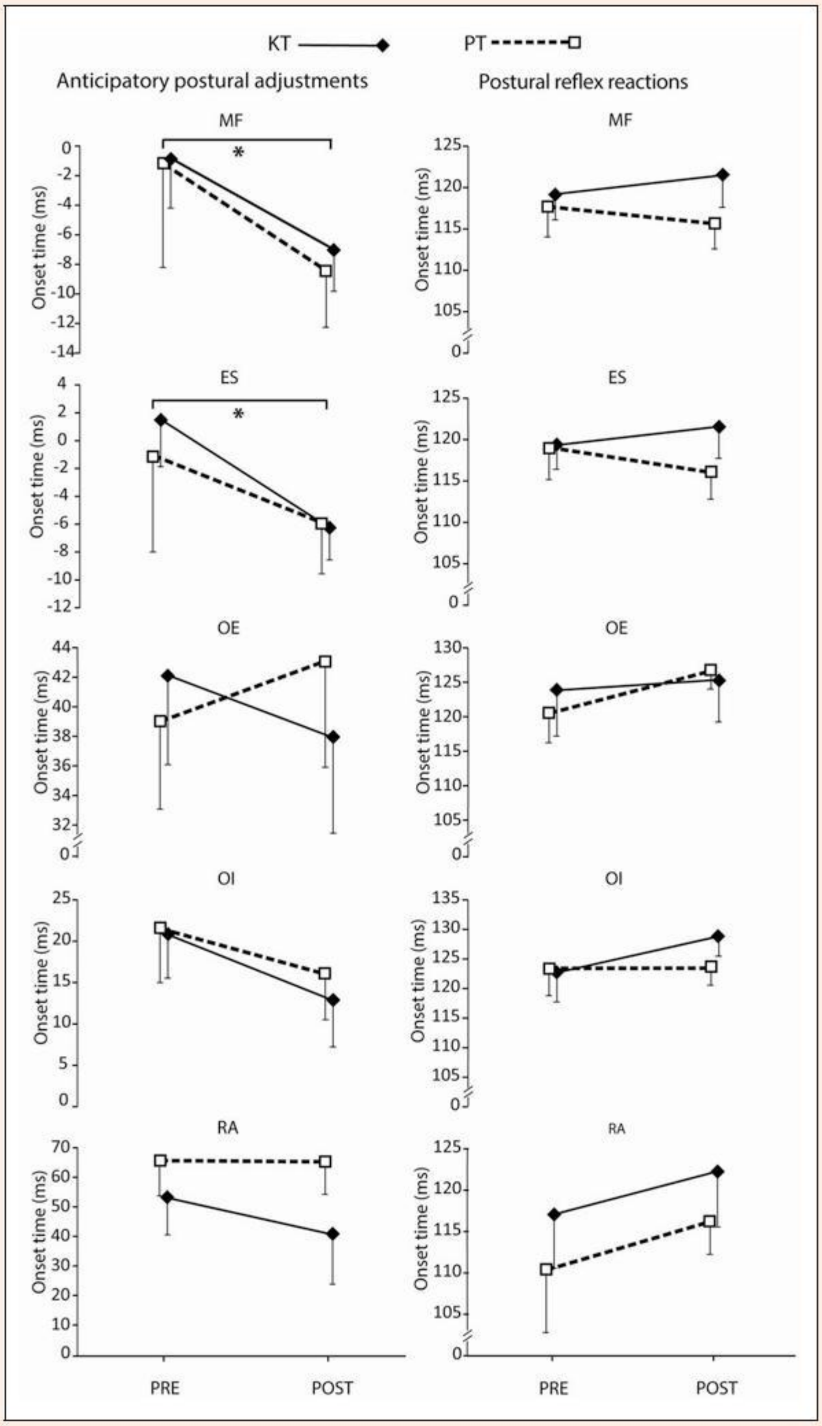

Figure 4. Mean (SE) timing of trunk muscles activation (erector spine at level L1 (ES), multifidus at level L5 (MF), obliquus externus (OE), obliquus internus (OI) and rectus abdominis (RA)) in measurements of anticipatory postural adaptations (APA) to fast voluntary arms movement and postural reflex reactions (PRR) to sudden loading of the arms before and after application of kinesio taping (KT) or placebo taping (PT). * Significant difference ($p < 0.05$)

muscles ES ($F_{1,11} = 5.02$, $p = 0.046$, $\eta^2 = 0.31$) and MF ($F_{1,11} = 6.18$, $p = 0.030$, $\eta^2 = 0.36$) but not abdominal muscles OE, OI and RA ($F_{1,11} < 3.27$, $p > 0.098$, $\eta^2 < 0.23$). *Post-hoc* bootstrap method confirmed time effect differences in case of ES ($p = 0.041$) and MF ($p = 0.033$). There were no significant differences between KT and PT condition for any of the analyzed muscles ($F_{1,11} < 0.23$, $p > 0.64$, $\eta^2 < 0.04$) and no significant interactions between condition and time factor ($F_{1,11} < 1.37$, $p > 0.27$, $\eta^2 <$

0.11) (Figure 4).

We found no statistically significant effects of tape application on timing of PRRs after sudden perturbation ($F_{1,11} < 4.16$, $p > 0.07$, $\eta^2 < 0.49$). There were also no differences between KT and PT condition ($F_{1,11} < 3.85$, $p > 0.08$, $\eta^2 < 0.49$) and no significant interactions ($F_{1,11} < 1.28$, $p > 0.21$, $\eta^2 < 0.13$) in any of the analyzed muscles (Figure 4).

Discussion

The goal of the present pilot study was to investigate the effects of KT application on the timing of trunk APAs and PRRs in young healthy participants. When compared to PT the application of KT had no significant effects on timing of back and abdominal muscles` APAs or PRRs. Interestingly, in measurements of APAs, both KT and PT application resulted in statistically significantly earlier activation of ES and MF muscles but there was no significant effect on timing of abdominal muscles. No such effects were seen on timing of PRRs.

There are few potential underling mechanisms that could at least partially explain our findings. One possible explanation is that stimulation of cutaneous receptors from tape application and consequently enhanced proprioceptive input does not affect spinal and supra-spinal level of motor control in a uniform manner. Another possibility could be that participants' expectations or increased awareness of trunk muscles activation had already resulted in earlier APAs after tape application. Afferent input from cutaneous receptors has been shown to influence excitability at spinal (Aimonetti et al., 2000;Iles and Roberts, 1987) and supra-spinal levels (Rosenkranz and Rothwell, 2012). Although PRRs are also under regulation from supra-spinal drive, they are primarily spinally regulated. In contrast APAs are generated at a supra-spinal level in a feed-forward fashion in an attempt to predict an upcoming postural perturbation and generate approximate corrections (De Wolf et al., 1998) . Various proprioceptive input stimuli have been shown to influence intra-cortical level of movement control differently and might change motor behavior (Rosenkranz and Rothwell, 2012). Results could indicate that afferent drive from taping application has more effect on supra- spinal levels of motor control since earlier activation was seen only in supra-spinally driven APAs.

It has been previously shown that timing of APAs can also be influenced by factors such as fear of pain (Moseley et al., 2004) or change in instructions (De Wolf et al., 1998). Perhaps earlier pre-activation could be a result of improved awareness or participants` beliefs. This could also explain the lack of difference between KT and PT since participants were unaware of the taping condition. Measurements were performed approximately one hour after the application of the tape when participants were accustomed to the sensation and generally did not perceive the presence of tape in any condition. No significant differences between the recommended KT application technique parallel over the muscle with tension and PT transverse application with no tension, is in contrast with results from the study done by Alexander and colleagues (2008). In their study, excitability of the gastrocnemius muscle only changed when taping was applied parallel to the muscle fibers potentially creating more skin traction during movement. In contrast to the present study they used non-elastic sport tape and not KT which could result in different stimulation of cutaneous receptors (Briem et al., 2011). Additionally, some authors have speculated that the response to KT application might be muscle specific (Alexander et al., 2008, Fratocchi et al., 2013). In our study both tests involved minimal movements of the taped segment, which potentially resulted in input that was insufficient to induce proprioception driven changes of muscle excitability.

Another possible mechanism that could influence postural control is the change in baseline muscle activation. Kase and colleagues [1] proposed that application of KT could stimulate Golgi receptors which induce inhibition of motor neurons in the central nervous system thus decreasing muscle activation. This was opposed by studies from Lins and colleagues (2013) in vastus lateralis and by Briem and colleagues (2011) in fibularis longus in which no effects of KT application on muscle activation have been shown. Briem end colleagues (2011) also compared if taping has different effects in a healthy population compared to subjects with chronic ankle instability; who have significantly higher activation of fibularis longus. Although application of KT did not show significant effect in any group they showed increased activation after application of non-elastic tape. Unfortunately, the authors did not report the amount of stretch used when applying KT. No effect of KT on PRRs after sudden perturbation is in agreement with findings from Briem end colleagues (2011) who found no changes in timing or amplitude of fibularis longus muscle activation after ankle inversion perturbation. Although the mechanical stimulation of cutaneous receptors can influence muscle excitability through suppressed presynaptic inhibition (Aimonetti et al., 2000) it seems that in young healthy subjects with an intact neuro-musculo-skeletal system, KT application does not provide sufficient afferent impulse to alter reflex reactions.

In pain free populations, as in case of the present study, sensory-motor control might be already near optimal and therefore additional afferent input does not induce changes of PRRs. In presence of low back pain, within and between muscles redistribution of activation and change in order of motor unit recruitment can be expected (for review see Hodges and Tucker). Paoloni and colleauges (2011) have shown that application of KT over back extensors has the potential to recover flexion relaxation phenomena (reduction of muscle activation in full flexion) in low back pain patients. Pain can also directly influence postural control. In an experimentally induced pain condition, delayed APAs and longer PRRs of trunk muscles were shown (Boudreau et al., 2011; Hodges et al., 2003). Application of KT in low back pain patients has indicated the potential to reduce pain (Castro-Sanchez et al., 2012; Lins et al., 2013), which could indirectly influence trunk stabilizing functions. The effects of KT on automatic stabilizing functions of trunk muscles in low back pain should be studied in the future research.

To our knowledge the present study is the first to investigate the effects of KT on automatic feed-forward and feed-back activation of trunk muscles. However there are some limitations of the study. Main limitation is small sample size and narrow age range of the participants therefore results cannot be extrapolated to the general population. Nevertheless, beside ES and MF muscles that reached significant difference in both conditions, none of the other muscles approached level of significance and the

Paoloni, M. (2013) Influence of Kinesio Taping applied over biceps brachii on isokinetic elbow peak torque. A placebo

effect estimations were low. Therefore similar results would be expected also with larger sample size. Although significantly earlier APAs of back muscles were shown after tape application, regardless the technique of taping, the results cannot be transferred directly to low back patients or to elderly populations since the study was performed on healthy young participants. Another limitation of our study is that we only investigated short term effects of KT application. Since we observed no short term differences between application methods any long term effects would not be expected after follow up.

Conclusion

There seems to be no differences in APAs and PRRs between KT application over lumbar paravertebral muscles and placebo application in young healthy participants. Observed earlier onset of APAs after both KT and placebo application might have clinically applicable value in low back pain patients. Future studies of KT application effects on sub groups of low back pain patients are thus warranted.

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Key points

- Application of Kinesio Taping does not affect postural reflex reactions in young healthy population.
- Earlier anticipatory postural adjustments were observed under both Kinesio Taping and placebo conditions.
- There were no significant differences between Kinesio Taping and placebo condition.

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