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Research article

Effect of 3 Different Applications of Kinesio Taping Denko® on Electromyographic Activity: Inhibition or Facilitation of the Quadriceps of Males during Squat Exercise

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Abstract

Kinesio taping consists of a technique which uses the application of an elastic adhesive tape. It has become a widely used rehabilitation modality for the prevention and treatment of musculoskeletal disorders. The objective of this study was to verify the effect of the application of Kinesio Taping *Denko*® in three conditions (facilitation, inhibition, and placebo) on the electromyographic activity of the quadriceps and hamstrings muscles on facilitating or inhibiting the muscle function and on the perceived exertion during the barbell back squat exercise in healthy male subjects. Methods: It was a randomized, single-blinded and controlled study in which 18 males (28.0 ± 6.7 years old; 85.8 ± 8.2 kg mass; 1.80 ± 0.07 m tall; 0.97 ± 0.04 m lower limb length) performed barbell back squat exercise with different conditions of Kinesio Taping *Denko*® applications: Facilitation, inhibition and placebo. Previous to the mentioned conditions, all individuals were assessed without applying kinesio Taping *Denko*® during the exercise. OMNI scale was used after each set for perceived exertion evaluation. No differences ($p < 0.05$) in the electromyographic activity of the biceps femoris, vastus lateralis and vastus medialis or OMNI scale were recorded under any conditions. The results show that the kinesio taping *denko*®may not alter the magnitude of the electromyography activity of vastus lateralis, vastus medialis, and biceps femoris during the squat exercise. Furthermore, the perceived exertion was not affected by the kinesio taping *denko*® application.

Key words: Kinesio taping, resistance training, biomechanics, squat exercise, electromyography.

Introduction

Kinesio taping (KT) is a technique which uses the application of an elastic adhesive tape on the skin. KT is manufactured with elastic cotton which can be stretched from 120 to 140% its original length. It is used to pressurize the skin to affect the somatosensory system under the areas where the tapes are applied (Kase et al., 2003).

KT has become a widely rehabilitation modality for the prevention and treatment of musculoskeletal disorders (Thelen et al., 2008). This technique has become popular after being widely used by athletes in the 2008 Olympic Games (Williams et al., 2012). It is claimed that KT supports injured muscles and joints and helps to relieve pain by lifting the skin, thus improving blood and lymph flow (Kase et al., 2003). It is also suggested that it brings a small immediate increase in muscle strength (Fratocchi et al., 2013; Hsu et al., 2009) by producing a concentric pull on the muscle fascia which may stimulate increased muscle contraction (Hammer, 2006). Additional hypotheses suggest that it facilitates muscle activity and improves muscle alignment (Hsu et al., 2009), increased range of motion (Hsu et al., 2009; Lewis et al., 2005; Thelen et al., 2008) and improves patellar alignment (Whittingham et al., 2004).

The type of the KT application determines theoretically the neuromuscular effects which are: a) the KT application from the muscle origin to insertion produces a concentric pull on the fascia, facilitating the muscle activation; and b) the KT application from the muscle insertion to origin produces eccentric pull on underlying fascia, inhibiting or decreasing the muscle contraction (Basset et al. 2010; Kase et al., 2003).

Some studies with surface electromyography (EMG) report that KT application may increase muscle activity. Csapo et al. (2012) applied KT (ktape®, biviax GmbH, Dortmund, Germany) over both heads of gastrocnemius muscle adjusted from muscle origin toward the insertion. They found an increase in EMG activity of gastrocnemius in only one of the five angles of the maximum isometric voluntary contraction (MVIC), though. Huang et al. (2011) found EMG activity of medial gastrocnemius increased in a KT group (Kinesio Tex KTX-050, Tokyo, Japan). Tapes were applied from calcaneus bone on the sole of the foot to medial and lateral gastrocnemius muscles below the knee joint. Briem et al. (2011) performed an ankle stability test, in fifty-one healthy male volunteers, where EMG activity of fibularis longus muscle was evaluated in placebo and kinesio tex gold elastic sports tape (Kinesio USA, LLC, Albuquerque, NM) conditions. A non-elastic white bandage was used as placebo. The only variable that showed significant changes was the average EMG activity which was higher in the placebo group when compared to group without any bandage. Hsu et al. (2009) reported that KT application increased EMG activity of lower trapezius muscle during shoulder abduction in amateur baseball players. On the other hand, Voglar and Sarabon (2014) found no differences between kinesio taping (Darco International, Inc., Huntington, USA) and placebo taping conditions in anticipatory postural adaptations. Lins et al.

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(2013) also found no differences in either EMG or torque peaks. They compared the root mean square (RMS) of muscles vastus lateralis, rectus femoris and vastus medialis during the knee flexion and extension in an isokinetic device at 60°/s without KT and non-elastic adhesive tape (kinesiotex gold®). Only Alexander et al. (2003) used a rigid tape (Endura Fix tape) applied without tension on the trapezius muscle compared to the elastic tape (Endura Sports tape) applied with tension. They found inhibition in EMG activity of lower trapezium.

The most recent systematic reviews have concluded that there is little quality evidence to recommend the usage of KT to prevent or treat musculoskeletal injuries (Morris et al., 2013; Williams et al., 2012); and regarding efficacy of KT applications to promote strength gains has recently been reviewed (Csapo and Alegre, 2015).

Williams et al. (2012) concluded in their meta-analysis that there was no substantial evidence to support the use of KT to enhance muscle activity. Their meta-analysis mentions that only one of the 16 studies analyzed concerning muscle activity has been verified with high methodological quality (controlled experimental study and blinding) and, thus, concluded that the placebo control is necessary for future research.

Only few studies have used some forms of placebo to compare results. Placebo is an inherent procedure with a similar therapeutic application, but without a specific effect (Moerman and Jonas, 2002). Among these studies, the placebo was conducted in different ways: KT transversely to the muscle fiber and without tension (Chang et al., 2010; Simsek et al., 2013; Thelen et al., 2008; Voglar and Sarabon, 2014); non-elastic tape (Briem et al., 2011); or micropore tape *3M*® (Hsu et al., 2009; Huang et al., 2011). These differences among placebo application in the studies could influence the expected results.

A single article used an analog visual scale (VAS) to check the performance (Cai et al., 2016), but they did not utilize the placebo control. This approach can help to analyze the subjective effect of KT. There are no studies that evaluate the effect of the KT on traditional strength exercises. Strength exercises are used in varied situations such as rehabilitation and performance increasing for sport training which represent most of the KT applications (Hsu et al., 2009; Huang et al., 2011; Thelen et al., 2008), whose effects are relevant in this kind of exercise.

Therefore, the aim of this study was to verify the effect of application of Kinesio Taping *Denko*® (KTD) in three conditions (facilitation, inhibition, and placebo) on EMG activity of mm. quadriceps and hamstrings on facilitating or inhibiting muscle function and on the perceived exertion during barbell back squat exercise. Our hypothesis was that KT application did not modify EMG activity during the strength exercises.

Methods

Subjects

Eighteen male adults (28.0 ± 6.7 years old; 85.8 ± 8.2 kg mass; 1.80 ± 0.07 m tall; 0.97 ± 0.04 m lower limb lenght) with no history of musculoskeletal disorders in the last six months participated in the study. Subjects had at least one year of experience in strength training and had been performing barbell back squat exercise with 8 repetition maximum (RM) at least once a week in the last six months (ACSM, 2009). Sample size was calculated based on coefficient of variation reported by Linset. al. (2013) and results in a minimum number of 15 subjects. Thus, 18 subjects were recruited to ensure a balanced order of experimental conditions application. The experimental procedure was approved by the research ethics committee of the University of São Paulo and all subjects signed a consent form.

Experimental design

EMG parameters and perceived exertion were evaluated during the barbell back squat exercise execution in four different conditions of applying kinesio taping *denko*® (KTD): without KTD; facilitation KTD; inhibition KTD and placebo KTD. Participants were oriented to adjust squat load to eight repetition maximum (8RM). It happened one week prior to the beginning of the experiment.

Experiment began with familiarization and warm-up procedures which consisted of four sets performed with two minute intervals between them: I) 15 repetitions with no load; II) 10 repetitions only with the bar (27 kg); III) 8 repetitions with 50% 8RM load; and IV) 4 repetitions with 8 RM load.

Five minutes after warm-up and familiarization procedures, four sets of 8 repetitions with 8RM load of barbell back squat exercise with five minute intervals between them were executed. For EMG normalization, the first set consisted of executing the exercise without the use of KT. The next three sets consisted of three different and random applications of the KTD, where each one of the six possible application orders was performed by three subjects (n=18). Between each series perceived exertion of participants was recorded using OMNI scale (Robertson et al., 2003).

Barbell back squat exercise

Barbell back squat exercise was conducted as follows: Standing position with a bar braced across trapezius muscle in the upper back. The movement was initiated by bending hips and knees (approximately 90 degrees), then returning to the upright position; as for the distance between subject's feet, it was equivalent to the biacromial width, and the load was equivalent to 8 repetitions as weight informed by volunteer himself. The bending control of the knee to approximately 90 degrees and the distance between feet were standardized during familiarization. All familiarization and experiment was supervised by an experienced personal trainer.

Each movement stage was controlled by a metronome which was set to one second for eccentric phase and one second for concentric phase. The rest, between the sets, was set to five minutes. Five minutes interval was enough recover bioenergetic system involved in the maximal force production (ACSM, 2009).

The 8 repetitions load was self-reported by the participants at the beginning of the session. Furthermore, participants were instructed to verify their 8 repetitions load by themselves during the week before test. Every volunteer was able to perform 8 repetitions of each one of the four series of the experiment. The average angle of knee flexion and the concentric and eccentric phases were assessed with a digital camera.

Kinesio Taping application

The trademarked tape used was "Nito Denko" (Osaka, Japan), and the person who applied it was a certified Physiotherapist. There were three different applications of Kinesiol taping *Denko*®: I) facilitation KTD, II) Inhibition KTD and III) placebo KTD.

First, a Point of Reference (PR), which started or ended the tape application, was found on each subject's thigh. Such PR was proximal to the anterior thigh (quadriceps) region and 1/5 of the distance between antero superior iliac spine (ASIS) and tibia tuberosity. Distance between PR to tibia tuberosity was used as reference to cut the tape to allow 20% tension of the tape. Orientation to apply the tapes through applications were: a) facilitation KTD: the tape was tensioned from PR on proximal region of m. quadriceps down to tibia tuberosity and, once it reached the knee, the tape was divided in the middle allowing it to circle the joint; b) inhibition KTD: tape was tensioned from tibia tuberosity up to two points in a perpendicular line to the proximal PR on m. quadriceps. On the knee, tape was divided in two, one part of the tape would follow lateral quadriceps and the other part of medial quadriceps (Kase et al., 2003); c) placebo KTD: tape was fixed on m. quadriceps with no tension (Figure 1). All applications were made according to the manufacturer's instructions and size of the tape was measured for each subject to ensure the exact level of stretch mentioned. All applications of KTD for all volunteers were performed by the same experienced and certified physiotherapist.

OMNI scale

OMNI scale is a verbal description and specific illustration of distributed intensity between numbers 0 and 10; where 0 is extremely easy and 10 is extremely difficult. This subjective scale of perceived exertion is an validated accurate scale for strength exercises (Lagally and Robertson, 2006; Robertson et al., 2003). All volunteers answered perception of exertion during interval of each series ofback squat exercise.

Data acquisition

Noraxon Telemyo 2400T G2 system (Scottsdale, Arizona) was used for EMG signal acquisition with sampling frequency and 16 bit resolution. This equipment has a 500x total gain (pre-amplifier 10x), an input impedance >100MOhns, a common mode rejection >100dB and baseline noise < 1 uV RMS. Ag/AgCl Noraxon dual electrodes (Scottsdale, Arizona) where an inter-electrode distance of 2 cm center to center were used. The electrodes were placed on the long head biceps femoris, vastus lateralis and vastus medialis following EMG for non-invasive assessment of muscle recommendations (Hermens, 2000).

Skin preparation for the electrodes placement consisted of shaving, soft abrasion with sandpaper and cleaning with alcohol. EMG signal was filtered by 4thorder band-pass Butterworth recursive filter with cutoff frequency of 10 and 450 Hz. For EMG data normalization, a 200ms moving window RMS with steps of 100ms was used for all conditions. RMS highest value under the WKTD condition was selected. All conditions were expressed as percentage of the highest RMS value.

Kinematic data were recorded by a digital camera (Panasonic, model PV-GS50S, 60Hz) and the knee flexion angle was measured using software Myovideo MR 3.4.6 (*noraxon*®-The United States).

Statistical analysis

Komolgorov-Smirnov test was applied to check data normality and the Levene test for the homoscedasticity. For comparison of RMS and perceived exertion among different applications, one-way repeated measure analysis of variance (ANOVA) was performed for each variable. The significance level was $p < 0.05$ and analyses were performed on Sigma Stat software 3.5.

Figure 1.Kinesio taping *denko*® applied on quadriceps muscle in different conditions. KTD, kinesiotaping *denko*®

Table 1.Root mean square of each muscle and OMNI range under the different kinesio taping denko® conditions. Data are means (±SD).

Kinesio Taping conditions	RMS values for each muscle			OMNI Range
	BF	VL	VM	
WKTD	76.30 (16.34)	75.04 (13.52)	73.95 (12.73)	7.8 (.9)
FKTD	77.01 (26.70)	77.84 (13.19)	79.73 (19.03)	8.2 (1.2)
IKTD	88.23 (26.34)	83.44 (18.94)	89.73 (21.47)	8.1 (1.2)
PL	78.14 (23.84)	81.03 (17.67)	79.97 (19.24)	7.9 (1.2)

RMS – Root mean square of electromyographic activity and OMNI scale - subjective perceptions of effort under the four experimental conditions during concentric phase. Values expressed as mean ± standard derivation. Experimental conditions: WKTD – Without kinesio taping *denko*®, FKTD – Facilitation kinesio taping *denko*®, IKTD – Inhibition kinesio taping *denko*®, PL – Placebo kinesio taping. BF - Biceps femoris; VL – Vastus lateralis; VM – Vastus medialis. OMNI – Range, where 0 is considered extremely easy and 10 extremely difficult. EMG was normalized by the RMS highest value under the WKTD condition. All condition are shown as percentage of the highest RMS value. None of the analyzed variables showed significant differences between the four conditions (p<0.05).

Results

Average knee flexion angle was 97.5± 4.8°. All variables showed normal distribution and equal variance. The load equivalent to 8 repetitions was 110.8 ± 31.3 kg. None of the variables showed differences among conditions ($p < 0.05$). Averages RMS (%) for each condition and OMNI scale are presented in Figure 2 and Table 1.

Discussion

A variety of brand names represents KT (Basset et al., 2010; Kase et al., 2003). To the best of our knowledge, we could find any study comparing different KT brands. The tape used in this present study followed the characteristics of the other studies which analyzed KT application. In our view, a comprehensive study (Pamuk and Yucesoy, 2015) has shown that the effect of KT application produces deformation to the skin and the surrounding tissue regardless of the orientation of KT application suggesting that KT type used would not be a factor to be considered.

In the present study, no changes were observed in magnitude of EMG signal for thigh muscles during barbell back squat exercise in these conditions: facilitation KTD, inhibition KTD, placebo KTD and without KTD. The results showed the application of KTD from the muscle origin to insertion did not increase, did not inhibit nor decreased muscle activity. The results suggest that isolated effects of KTD or the traction exerted by bandage in different directions is not be able to change the magnitude of the EMG activity. Facilitating or inhibiting effects of KT application protocol may be very simple in relation to the neuromuscular system complexity (Staudenmann et al., 2010). Through a magnetic resonance observation, the orientation of KT application on skin does not Deform-homogeneously the target tissue and as for others

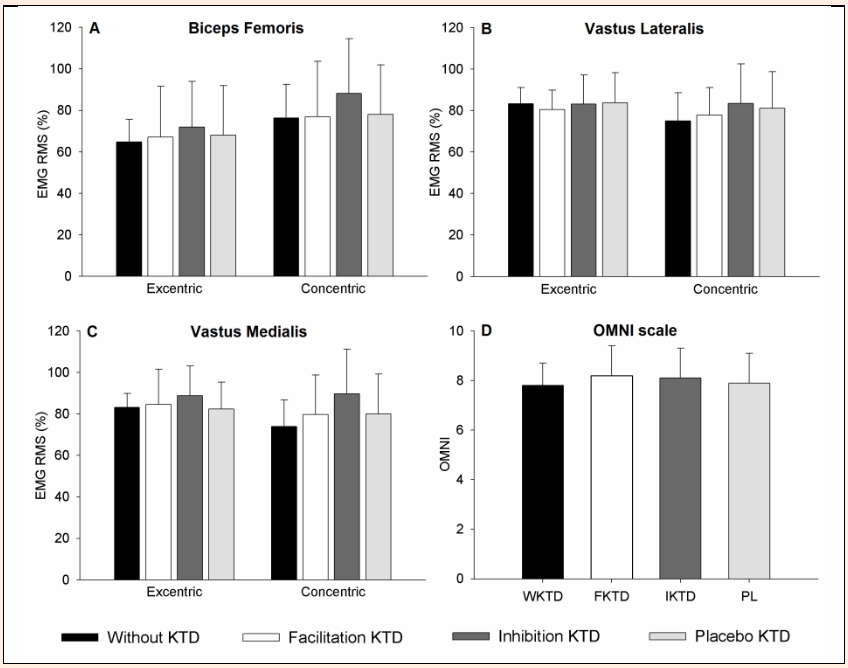

Figure 2.RMS, Root mean square of electromyographic activity and OMNI scale, subjective perceptions of the effort under the four experimental conditions during concentric and eccentric phases. Experimental conditions: WKTD, without kinesio taping *denko*®; FKTD, facilitation kinesio taping *denko*®; IKTD, inhibition kinesio taping *denko*® and placebo KTD, placebo kinesio taping *denko*®. OMNI scale, where 0 is considered extremely easy and 10 extremely difficult. EMG was normalized by the RMS highest value under the WKTD condition. All condition are shown as percentage of the highest RMS value. None of the analyzed variables showed significant differences between the four conditions ($p < 0.05$).

tissues, despite their distant and not being KT target (i.e., antagonist muscles) are also deformed regardless orientation of KT apllication (Pamuk and Yucesoy, 2015). In our study, there were no differences in biceps femoris muscle (antagonist) activations among conditions. The sensory effect of KT in personwith spinal cord injury (Tamburella et al., 2014) may be associated tospasticity. Confirming our results, an experimental study (Cai et al., 2016) did not find changes in EMG activity related to facilitation or inhibition due to the KT application in the wrist extensor muscles during a hand grip strength test performed by both genders.

All studies that found increments on EMG activity (Briem et al., 2011; Csapo et al., 2012; Huang et al., 2011; Hsu et al., 2009) did not show consistent results with the recommended KT method. However, we were the only who did load control, the speed control of muscle action and perceived exertion. We believe squat exercise was the most suitable choice to control all of these variables mentioned above. This option made it possible to control EMG activity in relation to strength (Staudenmann et al., 2010) and to get a standard on EMG activity when overload is equalized (Calatayud et al., 2015). Therefore, a non-significant result was found according to our hypothesis.

Kinematic data, allowed us to show that knee flexion angle was constant (97.5± 4.8°) in all conditions. However, researchers who evaluated subjects with some osteomyoarticular injury and in a way which could lead to a change in their posture have shown that KT application may increase joint range of motion (Hsu et al., 2009; Lewis et al., 2005; Whittingham et al., 2004). In our study, participants did not have any history of lesion or osteomyoarticular disease. The latter suggests that changes in joint motion do not occur in all of studied conditions due to KT usage (Kase et al., 2003).

Participants did no show different perceived exertion during barbell back squat exercise along conditions. Perceived exertion rate (7.8 ± 0.9 to 8.2 ± 1.2) corresponds to 80-90% of 1RM in the OMNI scale (Lagally and Robertson, 2006). The use of KT to improve performance (Kase et al., 2003) was not found. Cai et al. (2016) also have not found differences in the perception performance using VAS among subjects who had the KT application on their wrist extensor muscles. These authors did not mention VAS used in their study. Cai and co-workers results corroborate with ours showing that perceived exertion is not altered against different KT applications. Our results may represent higher practical applicability for physical technicians and coaches due to our using a scientific validated scale and an exercise protocol used very much during the athletes' physical training. We also controlled the execution speed of the concentric and eccentric phase in the barbell back squat exercise by using a metronome which guarantees a pattern in perceived exertion. In our study, the weight used during barbell back squat exercise was not altered and KTD was not able to promote changes in participants perceived exertion. Somehow, corroborating with the results of our research, meta-analysis study (Csapo and Alegre, 2015) concluded that KT application does not promote strength gains in healthy adults.

Until the present moment, KT application has been evaluated in different situations without controlling muscle action speed (Alexander et al., 2003; Csapo and Alegre, 2015; Williams et al., 2012) or with placebos of non-elastic tape. (Hsu et al., 2009; Huang et al., 2011) Only our study and Lins et al. (2013) controlled speed execution of squats. Lins et al. (2013) found no changes in EMG signal magnitude as we did. Finally, the possible effect of EMG activity inhibition (Alexander et al. 2003) may reflect a net effect of inhibitory nature (Pamuk and Yucesoy, 2015). These results corroborates with Willians et al. (2012). In their meta-analysis, there was no substantial evidence to support the use of KT to improve muscle activity, confirming our hypothesis.

Limitations

Our findings are limited to active healthy men engaging in recreational resistance training. Only men were chosen by us. It is a limitation of the study. Conclusions about perceived exertion effects and EMG activity of KT application with other muscle groups as well as in other cohorts, such as healthy elderly subjects, women and patients under a rehabilitation program require further investigation.

Conclusion

The results of the present study show that KTD applications do not alter the magnitude of EMG activity of vastus lateralis, vastus medialis, and biceps femoris during barbell back squat exercise. Furthermore, perceived exertion was not affected by KTD application.

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Key points

- Researchers involved in collecting data in this study have no financial or personal interest in the outcome of results or the sponsor.
- The perceived exertion was not affected by the kinesiology taping application.
- Kinesiology taping application may not alter the magnitude of EMG activity of vastuslateralis, vastusmedialis, and biceps femoris during the barbell back squat exercise.
- Electromyographic activity of kinesiology taping application on other muscle groups and in other cohorts, such as healthy elderly subjects and patients under a rehabilitation program require further investigation.

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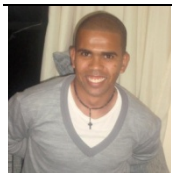

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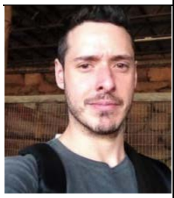

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