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Isokinetic knee function in healthy subjects with and without Kinesio taping

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ABSTRACT

Objective: This study examined the difference in the isokinetic knee performance in healthy subjects with and without the Kinesio tape application onto the skin surface overlying the vastus medialis.
Design: A cross-sectional experimental study.
Setting: Clinical setting.
Participants: 30 healthy participants.
Main outcome measures: Maximal concentric knee extension and flexion at three angular velocities (60, 120 and 180°/s) were measured with an isokinetic dynamometer. Normalized peak torque, normalized total work done and time to peak torque of knee extension and flexion were compared by repeated measures ANOVA.
Results: There was no significant main effect in ANOVA in normalized peak torque and normalized total work done between taping conditions and angular velocities. Conversely, participants demonstrated significant shorter time to peak extension torque with the tape condition ($p = 0.03$). Pair-wise comparisons indicated that such time reduction (36–101 ms) occurred at all three angular velocities ($p < 0.01$).
Conclusion: This investigation demonstrated the application of Kinesio tape did not alter the muscle peak torque generation and total work done but shortened the time to generate peak torque. This finding may contribute to the rationale in injury prevention and rehabilitation in athletes with Kinesio taping.

1. Introduction

Kinesio tape (KT) is one of the most commonly used stretchable tapes in sport injury prevention, rehabilitation of injured athletes and sports performance enhancement (Słupik, Dwornik, Białoszewski, & Zych, 2007; Thelen, Dauber, & Stoneman, 2008). KT and its method of application were first introduced by Kase in 1973 (Tsai, Hung, Yang, Huang, & Tsauo, 2009). According to the KT training manual (Kase, Wallis, & Kase, 2003), KT is highly stretchable (up to 75% of its original length) and its working mechanism is based on the taping direction and tension. Kase described KT applications for both "muscle facilitation" and "muscle inhibition" technique. KT applying from the muscle origin to insertion with stronger tension i.e. 50–75% of its original length may enhance muscle contraction (Kase et al., 2003). On the contrary, muscle contraction may be reduced by applying KT from the muscle insertion to origin with weaker tension i.e. 15%–25% of its original length (Kase et al., 2003).

In the last decade, a few research studies have evaluated the clinical effectiveness of KT. Application of KT has been shown to mitigate pain (García-Muro, Rodríguez-Fernández, & Herrero-de-Lucas, 2010; Kalichman, Vered, & Volchek, 2010), improve spin movement (Gonzalez-Iglesias, Fernandez-de-Las-Penas, Cleland, Huijbregts, & Del Rosario Gutierrez-Vega, 2009; Yoshida & Kahanov, 2007), and promote functional performance of patients with orthopedic and neurological conditions (Jaraczewska & Long, 2006; Murray & Husk, 2001; Yasukawa, Patel, & Sisung, 2006). To date, however, there is a limited amount of literature investigating the working theory of KT to facilitate muscle performance. Therefore, the current investigation attempted to examine the difference in isokinetic knee performance with and without KT application.

2. Methods

Based on previous sample size calculation (alpha = 0.05, Power = 80%, mean difference of 5 ± 10 Nm between taped and no-

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tape condition), thirty participants including fourteen males and sixteen females (mean age 28.4 ± 4.7 years, mean body mass 57.1 ± 11 kg) were recruited by convenient sampling from a local public hospital staff club. All participants were free from any known musculoskeletal and cardiopulmonary conditions. In addition, they were required to be free of any active joint pain or other related symptoms in the recent 12 months. The study was conducted according to the Declaration of Helsinki and the protocol was approved by the institutional review board before commencement. Written informed consent was received from all participants after a brief but detailed explanation about the aims, benefits, and risks involved with this investigation. Participants were told they were free to withdraw from the study at any time without penalty.

All the participants were asked to attend two isokinetic knee testing sessions. One of the sessions involved KT application onto the skin overlying the vastus medialis (VM) muscle. The sequence of receiving taping or not was randomized by tossing a coin. Two testing sessions were separated by at least seven days to avoid carryover effect (Fu, Wong, Pei, Wu, Chou, & Lin, 2008). Only the dominant leg, which was defined by the leg preferred to kick a ball (Ghena, Kurth, Thomas, & Mayhew, 1991), was tested.

Maximal concentric knee extension and flexion were measured by an isokinetic dynamometer (Biodex System 4, Biodex Medical Systems Inc., New York, USA). The isokinetic dynamometer demonstrated excellent test–retest reliability (Intraclass correlation coefficient = 0.82–0.95) in previous studies (Feiring, Ellenbecker, & Derscheld, 1990; Li, Wu, Maffulli, Chan, & Chan, 1996). The participants were tested in a seated position with hip angle at 100° and the testing knee was aligned with the axis of the lever arm attached. The pad of the lower leg attachment was positioned 5 cm above the lateral malleolus. The trunk and the thigh were stabilized by Velcro straps across the chest and the limb respectively (Fig. 1). The test range of motion was set at 0°–100° while 0° was defined as knee at neutral extension position i.e. anatomical zero.

The dynamometer was calibrated before each data collection session. Before testing, each participant performed standardized warm-up exercise (Five minutes low-resistance cycling) followed by a one minute rest. The measurements were taken at three different angular velocities (60°, 120° and 180°/s) for ten repetitions (Carregaro, Gentil, Brown, Pinto, & Bottaro, 2011). The order of the testing velocity was determined by a counterbalanced test sequence. The participants were allowed to have 60-s rest period between each set. Three trials of sub-maximal effort were given before each set of measurements to ensure familiarity. The participants were instructed to start the test once they saw the green light on the screen and heard the beep sound simultaneously. Standardized and consistent verbal encouragement was provided for all subjects using a script and they were allowed to receive visual feedback about their instantaneous performance from the monitor screen.

Peak torque is functionally defined as the mean of highest muscular force output of the ten repetitions and total work done is the amount of energy expended by the muscle for the entire set of testing. Time to peak torque is defined as the mean time from the onset of movement to the point of the peak torque in all trials. In this study, peak torque and total work done were normalized with body mass. These three parameters were used to determine the muscle performance.

The participants lied in the supine position with the hip flexed at 30° and the knee flexed at 50°. A two-inch (5-cm) Kinesio Tex tape was applied onto the skin overlying VM by the same investigator. The position and alignment of VM was confirmed by manual muscle testing prior to the application of tape (Kase et al., 2003). The KT was applied from the direction of origin to insertion with 75% of its maximal length tension, which was proposed to provide muscle facilitation effect (Kase et al., 2003). The tension of KT was confirmed by the anthropometric measurement of the tape i.e. measure the change in length of tape before and after being stretched. The technique of KT application was taken from the guidelines suggested by the original KT training manual (Kase et al., 2003) (Fig. 2).

All data were analyzed using SPSS version 17 (SPSS Software, Chicago, IL, USA). Repeated measures ANOVA was used to test the effects of KT and angular velocities on the normalized peak torque, normalized total work done and time to peak torque. The global alpha level was set at 0.05.

3. Results

The normalized peak torques of knee extension and flexion in different conditions are shown in Table 1. There was no significant difference in extension peak torque with and without KT and at different angular velocities ($F(2,28) = 0.24$, $p = 0.79$). Similarly, there was no significant difference in flexion peak torque in different conditions ($F(2,28) = 0.16$, $p = 0.86$). Similarly, there was no significant difference in normalized work done of knee extension and flexion between taped and control condition at any angular velocities (Extension: $F(2,28) = 1.51$, $p = 0.24$; Flexion: $F(2,28) = 0.28$, $p = 0.76$).

The time to peak torque corresponding to different testing conditions is shown in Table 1. Significant interaction effect was found between the taping conditions and different angular

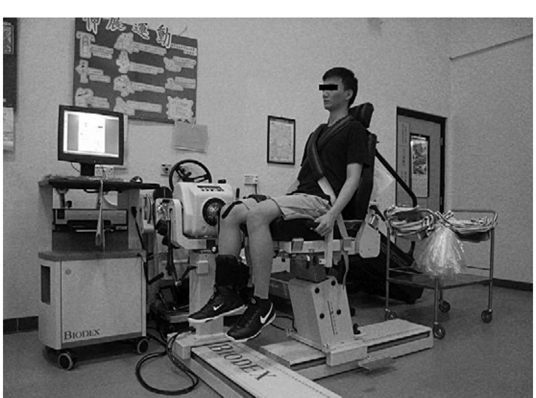

Fig. 1. The setting of the isokinetic test.

Fig. 2. Two-inch Kinesio Tex tape was applied on the skin overlying VM.

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Table 1
The comparison of mean normalized peak torques, mean normalized total work done and mean time to peak torque with and without application of Kinesio tape onto the skin overlying vastus medialis.

Measures		Velocity (deg/s)	Without tape[a]	With tape[a]	Mean difference[a]	95% CI	*p*-value
NPT (Nm/kg)	Extension	60	105.7 (21.1)	105.2 (23.2)	−0.5 (11.1)	−4.6 to 3.7	0.82
		120	88.5 (14.5)	89.0 (17.1)	0.4 (8.6)	−2.8 to 3.7	0.78
		180	75.5 (11.3)	75.6 (13.0)	0.1 (7.1)	−2.6 to 2.7	0.95
	Flexion	60	47.7 (14.0)	48.5 (15.4)	0.8 (4.7)	−1.0 to 2.5	0.37
		120	41.3 (12.8)	42.1 (14.2)	0.7 (4.5)	−0.9 to 2.4	0.37
		180	37.7 (11.9)	37.9 (13.4)	0.2 (5.5)	−1.8 to 2.3	0.82
NTW (J/kg)	Extension	60	542.9 (120.1)	511.2 (110.3)	−31.7 (60.3)	−9.2 to −54.2	0.07
		120	489.5 (95.1)	456.1 (99.4)	−33.4 (57.9)	−11.8 to −55.0	0.04
		180	418.6 (397.4)	397.4 (91.2)	−21.2 (52.0)	−1.8 to −40.6	0.03
	Flexion	60	264.5 (95.3)	263.4 (96.0)	−1.1 (33.4)	−13.5 to 11.4	0.86
		120	236.8 (91.2)	229.9 (99.8)	−6.9 (47.5)	−24.6 to 10.9	0.44
		180	203.9 (87.5)	199.8 (91.6)	−4.1 (45.7)	−21.2 to 13.0	0.63
TPT (ms)	Extension	60	618.7 (121.9)	517.3 (99.7)	−101.3 (122.4)	−147.0 to −55.6	<0.01*
		120	370.0 (45.9)	327.7 (52.2)	−42.3 (41.2)	−57.7 to −26.9	<0.01*
		180	277.0 (38.3)	241.0 (47.3)	−36.0 (45.4)	−52.9 to −19.1	<0.01*
	Flexion	60	552.7 (216.2)	506.3 (181.8)	−46.3 (184.7)	−115.3 to 22.6	0.18
		120	359.0 (87.0)	401.0 (141.4)	−42.0 (154.7)	−99.8 to 15.8	0.15
		180	319.0 (102.6)	317.3 (123.7)	−1.7 (137.1)	−52.8 to 49.5	0.95

NPT = Normalized Peak Torque, NTW = Normalized Total work done, TPT = Time to peak torque.
*Significant difference ($p < 0.01$) between two conditions (with Kinesio tape, without Kinesio tape).
[a] Value in bracket indicates standard deviation.

velocities for the time to peak torque in the main analysis of ANOVA ($F(2,28) = 4.02$, $p = 0.03$). Pair-wise comparison suggested that the time to peak torque in knee extension was shortened with KT application at all three angular velocities ($p < 0.01$) (Fig. 3). The time to peak torque difference in knee extension between two conditions ranged from 36 to 101 ms (Fig. 4). However, the time to peak torque in knee flexion remained unchanged with and without taping ($F(2,28) = 1.22$, $p = 0.31$).

4. Discussion

The current study set out to investigate the effects of KT on the isokinetic performance of knee muscles. The results indicated that KT does not significantly improve peak torque generation and total work done in healthy subjects. Such findings echoed the study conducted by Fu et al. (2008) that KT probably was not able to enhance muscle strength in healthy subjects. In order to enhance the muscle strength, a period of specific overload training would be required to promote neural activation and muscle fiber regeneration (Jones, Rutherford, & Parker, 1989). The tactile input generated by the KT might not be strong enough to alter the instantaneous muscle force output.

Interestingly, this study showed that time to the peak torque of extension was significantly shortened with KT application onto the skin overlying VM and this change was found at all three testing velocities. Another study comparing the onset timing and EMG ratio of VMO and vastus lateralis (VL) in taped and no taped condition (Chen, Hong, Huang, & Hsu, 2007) had demonstrated similar findings. They found the onset of VMO activity occurred significantly earlier in taped condition compared with control condition during stepping tasks. This phenomenon could be explained by a physiological mechanism.

A relationship between cutaneous afferent stimulation and motor unit firing in both central and peripheral nervous system has been established. An increase of peripheral nerve stimulation was shown to promote excitability of the motor cortex (Ridding, Brouwer, Miles, Pitcher, & Thompson, 2000). Reduction of motor neuron threshold may be induced by cutaneous stimulation, resulting in easier recruitment of motor units (Kandel, Schwartz, & Jessell, 1991). Stretching of skin over VM by therapeutic taping could specifically increase EMG activity of VM by elicitation of reflex contraction at the muscle underlying the area of stimulation (Hsu, Chen, Lin, Wang, & Shih, 2009; MacGregor, Geriach, Mellor, & Hodges, 2005). In the current study, the KT application was suggested to provide tactile input and stimulate the cutaneous mechanoreceptors and such stimulation might alter the firing time of the motor neurons, but not be strong enough to enhance muscle strength.

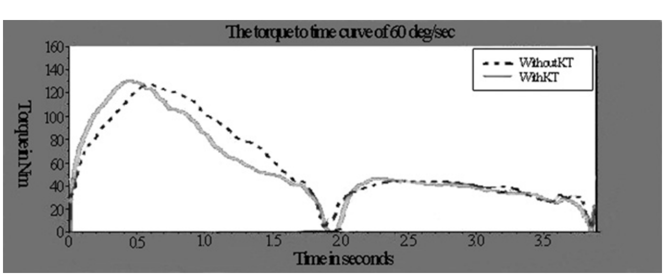

Fig. 3. The isokinetic torque–time curve with and without KT.

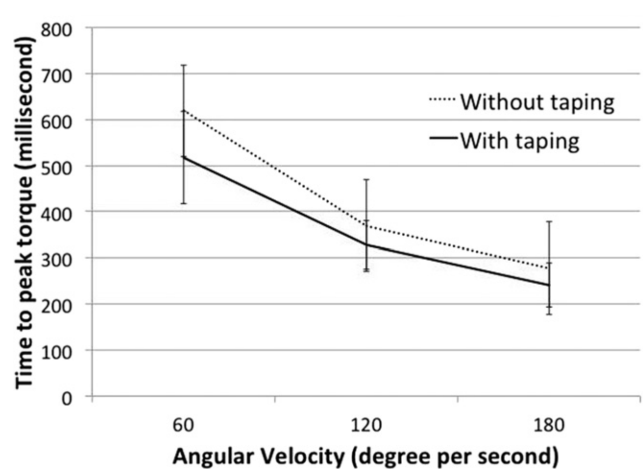

Fig. 4. The time to peak torque difference in three velocities.

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Time to peak torque indicated the recruitment rate of motor unit (Dvir, 2003) and type II muscle fibers (Kannus, 1994). A biomedical study, which analyzed muscle biopsy from 150 individuals, reported that approximately 60% of type II fibers were found at the superficial layers of quadriceps muscles (Staron et al., 2000). Taken together, the sensory input by the KT application may facilitate the muscle recruitment and thus, the time of peak torque can be shortened.

The current study suggested that the time to peak torque of quadriceps could be shortened by 36–101 ms with KT application. Clinically, early occurrence of peak torque generation in specific muscle groups might contribute in injury prevention and rehabilitation of musculoskeletal problem such as patellofemoral pain syndrome (Cowan, Bennell, Hodges, Crossley, & McConnell, 2001). A group of studies (Cheung & Ng, 2009; Cowan et al., 2001; Neptune, Wright, & van den Bogert, 2000) reported that the amount of delay in VMO onset relative to VL which may lead to patellofemoral pain syndrome ranged from 3.4 to 10 ms. Altering the peak torque generation time by KT application might promote favorable biomechanics and improve the symptoms in a patient population.

However, there is a lack of evidence to associate early occurrence of muscle peak torque generation and sports performance enhancement. The KT application for athletes aiming for better performance was thus not supported by the current findings.

There were several limitations in this study. First of all, this study only examined an immediate effect after taping. The carry-over effect of the tape was not investigated. Secondly, there was no true control group or placebo taping to eliminate the psychological effect of the tape. Therefore, we did not exclude the potential of placebo effects to cause the observed differences in subjects with KT application. Thirdly, the tension of the KT was standardized by measurement of the length of tape, which resembled the clinical situation. The experimental setup might be improved by actual standardization of the tension of the tape using a strain gauge.

Three research areas were recommended for future studies. The performance in isokinetic testing might not be comparable to sports performance. Therefore, further research is recommended to examine the association of sports performance with therapeutic tape. The exact mechanism(s) for the time to peak torque reduction by KT application is still unclear. Further physiological study is recommended to investigate the physiological effect and actual working mechanisms of the application of elastic taping.

5. Conclusion

The present study demonstrated that the KT application onto the skin overlying VM did not alter the muscle peak torque generation during concentric knee extension and flexion. However, KT application was found to shorten the time to generate peak extension torque.

Conflict of interest

None declared

Ethical approval

The protocol was approved by the institutional review board.

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None declared

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