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Original research

Influence of Kinesio Taping applied over biceps brachii on isokinetic elbow peak torque. A placebo controlled study in a population of young healthy subjects

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ABSTRACT

Objectives: To investigate the effect of Kinesio Taping (KT) applied over the biceps brachii on maximal isokinetic elbow torque.
Design: This study followed a single-blinded, placebo controlled, repeated measures design.
Methods: Isokinetic eccentric and concentric elbow peak torques were evaluated without taping (NT), with KT or placebo taping (PT) in 20 healthy participants. Furthermore, all the participants were required to perform a proprioceptive task of elbow joint position sense (JPS) in the same experimental conditions.
Results: A significant effect of taping condition was found for concentric elbow peak torque ($p = 0.01$). Post hoc analysis revealed a statistically significant concentric elbow peak torque improvement between NT and KT ($p < 0.05$) but not between NT and PT. As regards eccentric elbow peak torque, we found a significant effect of taping condition ($p < 0.0001$). Significant eccentric elbow peak torque differences were observed between NT and PT ($p < 0.01$) and between KT and PT ($p < 0.001$), while the increase observed from NT to KT conditions failed to reach significance at a post hoc analysis.
Conclusions: When applied over the biceps brachii, KT increases concentric elbow peak torque in a population of healthy participants, if compared with a PT.

1. Introduction

Kinesio Taping (KT) represents an interesting and relatively new modality to treat musculoskeletal conditions, both for rehabilitation and sport medicine purposes. Kinesio Tape is elastic tape that differs from the traditional cotton non-elastic tape because of its ability to stretch up to 140% of its original length, thereby providing a constant shear force on the skin. KT was conceived to be therapeutic and, according to its creators, yields the following results[1]: it corrects muscle function by strengthening weak muscles; it improves blood and lymph circulation by eliminating tissue fluid or bleeding beneath the skin through muscle movement; it reduces pain through neurological suppression; it corrects misaligned joints by relieving muscle spasm. Pain relief by means of KT has been demonstrated in a number of conditions, including rotator cuff tendonitis[2], shoulder impingement syndrome[3], acute whiplash[4] and chronic low back pain[5]. The interaction of KT on muscle function has also been tested in a number of experiments: Slupik et al.[6] demonstrated an increase in the electromyographic (EMG) activity of the vastus medialis muscle after 24 h of KT, as well as the maintenance of increased motor activity in this muscle after 2 days of KT, and even following its removal. Moreover, when applied on the lower trapezius of baseball players affected by shoulder impingement syndrome, KT facilitated lower trapezius muscle activity, as measured by surface EMG, during the lowering phase of the abduction on the scapular plane tasks[7]. The application of KT over the upper trapezius muscle in a group of 12 asymptomatic subjects resulted in significant changes in EMG activity in the scapular muscles[8]. The authors of this last study found that KT also enhanced proprioceptive feedback, thereby speculating that the mechanism through which scapular KT acts was shared by both neuromuscular control and proprioceptive feedback. However, even though its facilitating effect on muscle activity seems to be proven, data regarding the capacity of KT to increase muscle strength are still controversial. Aktas and Baltaci[9] described a significant increase in isokinetic knee extension peak torque at 180°/s following KT application over the thigh, thereby suggesting that its application could be useful during rehabilitation to support knee musculature. Contrarily, Fu et al.[10] found no differences in isokinetic strength in 14 young athletes following the application of KT on the thigh's anterior surface. Chang et al.[11] applied KT on the forearm of 21 healthy collegiate athletes. Although KT enhanced both related and absolute force sense, it did not change maximal grip strength. The ability

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of the neuromuscular system to generate force and maximal power is, however, affected by a range of factors. Both the type of muscle action involved and muscle-specific morphological factors, e.g., impact the ability to generate maximal force and power[12]. From this point of view, we hypothesized that the effect of KT is likely to be muscle-specific. In order to test if the application of KT over the biceps brachii muscle could improve muscular strength, we decided to evaluate isokinetic concentric and eccentric elbow peak torque in a group of healthy participants in three different conditions: without taping (no taping: NT), with KT or with a placebo taping (PT). Moreover, as KT application has been associated with changes in proprioceptive function, we also tested the hypothesis that changes in muscle strength, if present, are likely to be accompanied by changes in an indirect measure of proprioception, such as elbow joint position sense (JPS).

2. Methods

Twenty healthy voluntary subjects (17 males and 3 females; mean age 23.6 ± 2.3 years) who practiced sport activities that does not include upper limb training specific programs, gave their written informed consent and participated in the study, approved by the ethics committee of "Sapienza", University of Rome. The study complied with the terms of the Helsinki Declaration relating to human experimentation. The exclusion criteria included a history of traumatic disease of the spine or upper limbs and severe cardio-respiratory, neurological or metabolic disease. In order to avoid any influences on attention and performances, subjects were asked not to take any psychoactive agents in the 24 h prior to participation in the study and the trials were not performed in case of sleep disturbances the night before the recording. Subjects were also asked not to perform any physical activity involving upper limbs in the 24 h preceding the test session.

An Isokinetic Pulley System (IPS, Moflex, Recotec/Bernina, Switzerland) was used to assess isokinetic concentric and eccentric elbow torque (Fig. 1). The dominant arm was determined in all the participants by means of the ball launch test (right side in all the participants). The test, which was performed with the subject comfortably seated, started with the arm vertically extended down the side of the trunk. The participant was asked to hold a handle tied to a cable connected to a hydraulic motor that adjusts muscle force resistance for each movement degree, and instructed to completely flex the elbow, keeping the arm close to the trunk (concentric evaluation), and, immediately after this flexion, to resist a complete elbow extension movement (eccentric evaluation). Standardized verbal encouragement was given during performance of the test and continuous supervision provided to ensure that no abnormal movements of the trunk or the shoulder occurred during the test procedures. Dedicated software was used to control the IPS machine and to provide a real-time graphic displaying the strength expression during both movements. This visual feed-back was used as a mean to further provide encouragement to participants while performing movements. A short, 5-min warm-up exercise was performed before each test session. Peak torque for flexion and extension was tested at 0.40 and 0.20 $m\,s^{-1}$ respectively. Firstly, participants ran one test set to familiarize with the exercise. Participants performed 3 sets of concentric/eccentric contractions, with a 3-min rest between each isokinetic repetition. The peak torque was defined as the peak value obtained from the 3 trials measured in Newton meters. Three different conditions were randomly tested for each subject, i.e. NT, immediately after KT application, and immediately after the application of PT; concentric and eccentric elbow peak torques were then calculated for each patient in all the tested conditions. The order of the three tested conditions was randomized using a random number allocation table. To avoid any bias resulting from muscle fatigue induced by the previous isokinetic assessments, an inter-assessment interval of at least 5 days was allowed.

Elbow JPS, an indirect measure of proprioception[13], was performed with the participant sitting, using a simple protocol similar to that used by Goble and Brown[14]. An experimenter passively flexed the elbow through five different positions (20–140° flexion, in 30° intervals) whilst the participant's eyes were closed. The participant then held the test position, 'sensing' the joint position. Upon return to the resting position, the participant was asked to flex the elbow to the perceived test position (response position). Each proprioceptive test was repeated nine times: three with NT, three with KT and three with PT, in a randomized order, using ten proprioceptive questions for each test. Elbow angles were calculated using computer analysis of photogram (Adobe® Photoshop® CS5) taken during the test with a fixed camera on a tripod positioned laterally to the participants. The trial was considered exact (i.e. subject provides a good repetition of the test position) if the difference between the test position and the response position was ±2.5°.

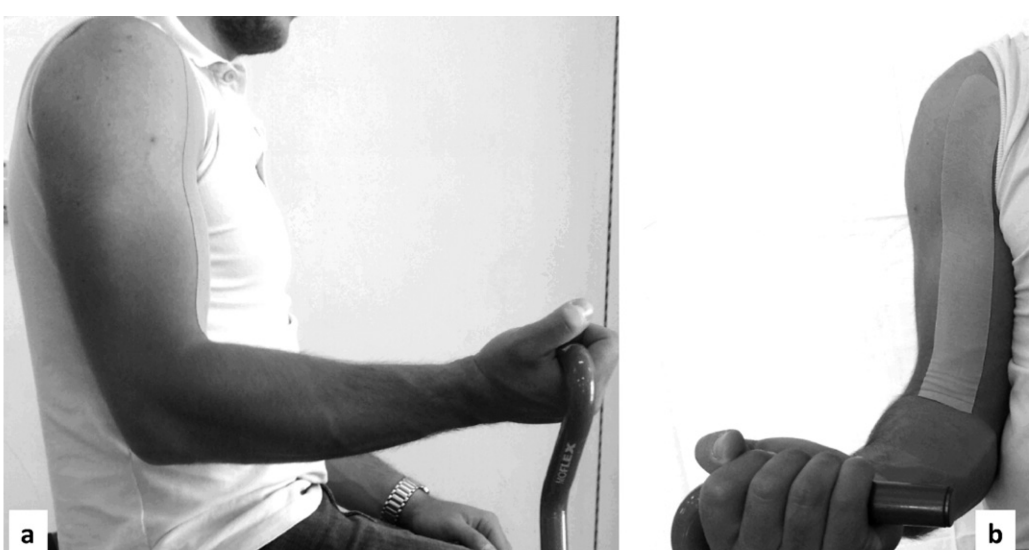

Fig. 1. a participant performing a bicep contraction on the isokinetic pulley system. Lateral (a) and frontal (b) view.

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The KT consisted of a 5 cm strip of a thin, cotton, porous, adhesive, latex-free, elastic tape with a longitudinal elasticity of 40% (Kinsiotape KT545, Visiocare s.r.l., Vedano al Lambro, Italy), applied over the entire length of the biceps muscle in all the participants.

The tape was applied, starting from biceps muscle distal insertion to the origin, in such a way as to embrace the sides, stretching to approximately 75% of its overall flexibility, and cover the entire muscle. The ends of the "I-strip" tape (about two fingers) were attached without applying tension to the tape (Fig. 2a).

The PT consisted of two "I-strips" (10 cm) of the same tape (Kinsiotape KT545, Visiocare s.r.l., Vedano al Lambro, Italy) applied without tension transversally across the proximal and the distal portions of the biceps muscle belly (Fig. 2b).

The statistical analysis was performed using SPSS version 18 (SPSS Inc., Chicago, Illinois). Data normality was verified by means of the Shapiro–Wilk test. The mean value ± standard deviation (SD) of each parameter was calculated in all conditions (NT, KT and PT) and for each exercise (concentric and eccentric evaluations). Repeated measures one-way analysis of variance (ANOVA) or Friedman ANOVA were used, as appropriate, to evaluate differences across the three tape conditions both for concentric and for eccentric evaluations. Post hoc pairwise comparisons with Bonferroni correction were conducted to determine where significant differences existed. The χ^2 test was used to determine differences in the number of exact trials at JPS evaluation across the three conditions. For normally distributed variables, estimates of effect size were analyzed using the partial eta-squared method to describe the proportion of total variability attributable to each factor. The level of significance was set at $p < 0.05$.

3. Results

The Friedman ANOVA of the concentric elbow peak torque revealed a significant effect of taping condition ($\chi_r^2 = 8.4$, $p = 0.01$; DF = 2). Post hoc analysis revealed that concentric elbow peak torque was significantly higher in the KT condition when compared with NT (Δ rank sum = −18; $p < 0.01$). No other significant differences were found (Table 1). The repeated measures ANOVA of the eccentric elbow peak torque revealed a significant effect of taping condition (F = 16.022, $p < 0.0001$; DF = 2). Post hoc analysis revealed a statistically significant increase of eccentric peak torque in the KT condition when compared to PT (Δ = 38.4; 95% CI of Δ = 20.97 to 55.82; $p < 0.001$) and in the PT condition when compared to NT (Δ = 26.8; 95% CI of Δ = 9.373 to 44.23; $p < 0.01$). No significant differences emerged between KT and NT conditions (Δ = −11.60; 95% CI of Δ = −29.02 to 5.831; $p > 0.05$) (Table 1).

The percentage of exact trials at JPS evaluation was 51.3% with NT, 43.3% with KT and 52% with PT, which was not significant at χ^2 test (χ^2:1.00; $p = 0.61$). The effect size for eccentric peak torque was 0.45.

4. Discussion

The aim of the present research was to determine the effect, if any, of the application of KT on isokinetic concentric and eccentric elbow peak torque. We also tried to search possible changes on elbow JPS following KT application. In summary our results indicate that: (i) KT determined a significant increase of concentric elbow peak torque when compared with NT and a significant increase of eccentric elbow peak torque when compared with PT but not with NT; (ii) PT determined a significant decrease of eccentric elbow peak torque when compared with KT; (iii) elbow JPS was not affected by KT or PT application.

To our knowledge, only little data exist in which KT has been shown to exert an immediate effect on muscle strength in an experimental setting. Indeed, although its creators claimed that the application of KT increased muscular strength[1], recent studies had failed to confirm this hypothesis[10,11]. Interestingly, Fu et al.[10]

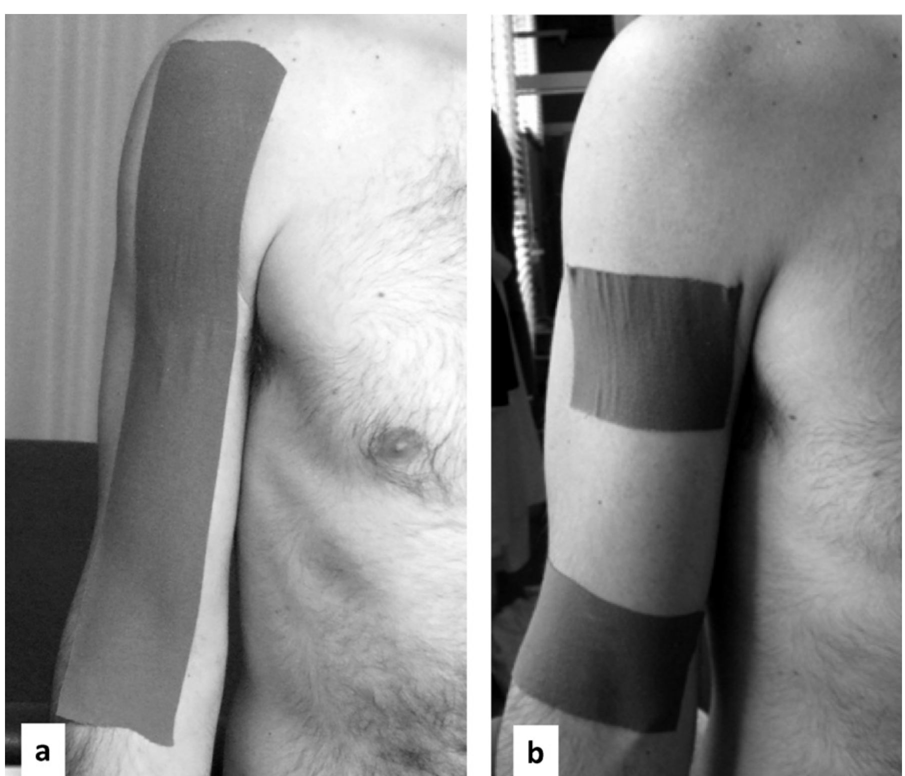

Fig. 2. Kinesio Taping (b) and placebo taping (b) over the biceps brachii muscle.

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Table 1
Comparison between NT and KT and PT values of eccentric and concentric isokinetic elbow peak torque.

	NT (n = 20)	KT (n = 20)	PT (n = 20)	p
Concentric elbow peak torque, N/m	52.6 (24.7)	59.4 (31.7)	53.1 (27.4)	0.01[a]
Eccentric elbow peak torque, N/m	68.5 (32.5)	80.1 (39.7)	41.7 (20.5)	<0.001[b]

Values are the mean (SD). NT = no taping; KT = Kinesio Taping; PT = placebo taping.
[a] Friedman ANOVA.
[b] Repeated measures ANOVA.

already found an increased concentric quadriceps peak torque after KT application over the thigh, but they interpreted this finding as the consequence of a type II error. There are, however, some noteworthy differences between our study and those conducted by Fu et al.[10] and by Chang et al.[11]. Both these studies were conducted on athletes, who presumably already have a good level of muscle strength. One may speculate, therefore, that the small degree of measurable effect (increase in muscular strength) in those subjects may have determined a low study power[15]. We, in fact, decided to assess the effects of KT in non-athletes, in whom we hypothesized the increase of muscular strength would be more detectable than in professional athletes. From this point of view, it is worthy of note that we found for eccentric peak torque an effect size of 0.45 which could be considered as a quite large effect. Technical considerations related to the taping procedure may also explain the differences between the results of this paper and those reported in the paper by Fu et al.[10]. Indeed, in the latter study, the tape was applied with the joints flexed, it did not cover the entire length of the muscle, and the tape stretch tension was far below its potential. Our procedure instead required application of KT over the entire length of the muscle, with the joint in extension, using a traction corresponding to approximately 75% of the tape potential elasticity. Further studies designed specifically to compare different taping procedures over the same muscles would be helpful to confirm this hypothesis. Furthermore, as the type of muscle action involved and muscle-specific morphological factors impact the ability to generate maximal force and power[12], one may argue that the effect of KT is likely to be muscle-specific. This hypothesis remain to be tested by proper studies comparing different site of KT application.

Difficulties in proper interpretation of changes in neuromuscular functions following KT application come from uncertainties about its exact mechanism of action. Although determining the mechanism underlying the effect of KT is beyond the scope of this study, some speculations may be made in an attempt to understand how KT provides increase in elbow torque. The hypothesis that elastic tape simply stores kinetic energy in a spring pin (tape) fashion would not justify the changes in eccentric torque. The increased strength we observed is more likely to be due to the neurophysiologic influence exerted by the tape. Force production results from a series of electrochemical processes, initiated in a muscle fiber by the firing of its associated α-motoneuron. Motor unit recruitment patterns vary during natural movements (not always respecting the size principle), and it has been suggested that motor unit recruitment is related to the mechanical function of the muscles. Many factors, such as auditory and visual feedback[16], variations in proprioceptive inputs[17] and cutaneous stimulations[18], alter recruitment orders[19]. A given sensory stimulus may, indeed, affect motor output through a number of parallel, or alternative, segmental pathways belonging to different 'functional units'[20]. Interestingly, KT application over the Achilles tendon seems to facilitate calf muscle motoneuronal excitability in healthy subjects, though not in those affected by Achille's tendinopathy[21]. This is in contrast to the effect of a rigid tape, which reduces calf motoneuronal excitability when placed along the gastrocnemious muscle belly; this reduction is presumably due to a shortening effect of the rigid tape on the muscle fibers, which in turn reduces the Ia drive from the muscle spindle and, consequently, the drive to the motoneuronal pool[10]. However, given the thickness of KT, it seems unlikely that its application may deform the tendon or muscle[21]. One suggestive hypothesis is that other afferent inputs, particularly those deriving from cutaneous afferents, modulate motorneuronal excitability and, as a consequence, force output when KT is applied. This hypothesis cannot be confirmed on the basis of our data, but needs to be tested in further studies designed for this purpose. It has been speculated that tape procedures may adjust muscle activity through proprioceptive feedback[22]. According to the results of our study, however, the application of both KT or PT, actually does not significantly influence performance in the JPS task. However, as we did not measure the direction in which the error occurred during the JPS evaluation, the possibility that an altered proprioceptive function occurred in one direction and that this influences force output in our participants during KT application cannot be completely ruled out.

If confirmed in sub-populations of patients with a documented muscular weakness, results from the present study may potentially positively impact neuromuscular rehabilitation of various pathological conditions. Patients undergoing rehabilitation, in fact, often show a reduced muscular strength[23–25] and intervention aiming to reduce strength and power deficits are generally recommended[26,27]. One may therefore argue that during therapeutic exercise performed for rehabilitation of both orthopedic and/or neurological diseases, a slight increase in strength produced by proper KT application can be helpful.

One limitation of our study is that our results are based exclusively on isokinetic measurements, a form of muscle contraction that does not commonly occur in daily neuromuscular function. Indeed, it would be interesting to investigate whether also KT improves strength related to other types of muscle contraction. The values of both concentric and eccentric elbow peak torques in the no-tape condition are, however, in line with those reported in current literature[28,29], and it is noteworthy that a very close relations between maximal isokinetic and isometric strength was recently found in a population of non-athletic healthy subjects[29]. Another potential limitation of our study is the movement we analyzed – indeed, during movements on a vertical plane, as occurs in biceps flexion, gravitational force may become "contrasting" (during the concentric phase of contraction), or "helping" (during the eccentric phase of contraction). Lastly, as we only measured immediate effects of KT application, studies are warranted to determine how long these results are maintained.

5. Conclusion

When applied over the entire length of the biceps brachii, KT determines an immediate increase of concentric elbow peak torque if compared with NT, and of eccentric elbow peak torque if compared with PT in a population of young healthy participants. This changes in elbow peak torque did not appear to be related to aspects of increased proprioception that stretched tape on the skin could determine. Further studies are warranted to determine whether KT exerts the same effect on maximal peak torque in non-isokinetic contraction conditions, to determines long-term effects of KT application and to shed more light on

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the underlying mechanisms of action of KT on force production.

Practical implications

- When applied over the biceps brachii muscle, an elastic tape stretched around the skin can produce an increase in elbow peak torque within a series of isokinetic contractions.
- This increase in elbow peak torque did not appear to be related to aspects of increased proprioception that stretched tape on the skin could determine
- Both during sports activities and during therapeutic exercise performed for rehabilitation of both orthopedic and/or neurological diseases, a slight increase in strength produced by proper KT application could be helpful.

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