The Effect of the Inhibition Technique of the Kinesio Taping on the Triceps Surae Muscle after an Isokinetic Fatigue Protocol

Abstract

Study Design: Randomized controlled single blind pre-post experimental study.

Objectives: To reveal the effects of Kinesio Tape on the fatigue of the triceps surae muscle in healthy male individuals, as compared to sham tape application.

Background: taping is commonly used in the field of musculoskeletal and sports physical therapy and its usage gained in popularity. Limited researches with contradictory results are available in regards to the effect of the KT application on muscle fatigue.

Methods: Seventy healthy male participants have volunteered for this study and randomly assigned to 1 of 2 groups: therapeutic KT group or sham KT group. Only the dominant leg was taped. Each participant took 15 minutes warm up before heading to the isokinetic dynamometer. Then, participants were instructed to do 3 maximal force plantar flexion contraction followed by 50 consecutive maximal contraction ended by 3 final contractions. Peak torque and total work were measured after the first and third trial and fatigue index was calculated after the fatigue protocol.

Results: the sham KT group showed significant decrease between the pre fatigue and post fatigue values (p = .000), whereas the therapeutic KT group did not experience the same reduction of values after the fatigue protocol (p = .600). Regarding the fatigue index, there was a significant difference between the sham KT group and the therapeutic KT group (p = .001)

Conclusion: KT may help to reduce and delay the muscle fatigue if applied prior any functional activity.

Keywords: Muscle fatigue; Muscle tone; Adhesive taping; Rehabilitation

Research Article

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Introduction

Over the last three decades, the uses of elastic adhesive taping methods have gained in popularity especially during the Olympic competitions in 2008 [1-3]. After lot of research and experimentations, Dr Kenzo Kase [4] pioneered the introduction of the Kinesio Taping (KT) in Japan in the late 1970s, as a new form of applying the adhesive tape. The tape is made of a polymer elastic and adhesive strand wrapped by 100 % cotton fibers which can be stretched up to 140% of its original and resting length. So by applying this elastic tape we may achieve a less constraining mechanism in comparison with more rigid conventional tape. The above-mentioned tape has approximately the same thickness as the human skin epidermis [4]. As for its biomechanical effects, Taping has been recognized for its ability to lift the skin from the underlying fascia and soft tissue, which results in an increasing in blood circulation and enhances the lymphatic flow, hence leading to an increased oxygen allotment to the muscles and a noticeable attenuation of any inflammation [4]. On the one hand, medical doctors, physical therapists, occupational therapist chiropractors and certified athletic trainers have been using the elastic taping in their clinical practice when treating orthopedic and sport injuries, yet, limited research with contradictory results has been conducted to evaluate the real effectiveness and mechanism of the taping applications [2,5,6].

According to Williams et al. [3] that conducted a meta-analysis and included five studies investigated the effect of Kinesio tape on muscle tone [1,7-10]. They concluded that Kinesio Tape is having at least a small beneficial effect on muscle strength. They also suggested more researches to be established in similar muscles and investigating the long term effect of Kinesio Tape. More recently, Csapo et al. [11] conducted a meta analysis on the effects of Kinesio taping on skeletal muscle strength. They included 19 studies used a non-controlled repeated measurement design with moderate level of evidence. They concluded that the usage of Kinesio tape for increase muscle strength has no or negligible results in different muscle groups.

Limited studies addressed the effects of Kinesio Tape on muscle fatigue. Yeung et al. [12] did not find any changes in regards of increasing muscle peak torque and total work after an isometric fatigue protocol following application of Kinesio Tape on vastus

medialis muscle. However, Alvarez et al. [13] found that Kinesio Tape improved the time to failure of the extensor muscles of the trunk when they measure the endurance of the extensor muscles of the trunk using the Biering-Sorensen test. More researches have been investigated the effects of Kinesio Taping on facilitating or inhibiting the muscle tone immediately after tape application or the short term effect after application. There are numbers of researchers who reported a significant difference in the muscle tone after the application of the tape [9,14-20]. However, Kinesio Tape was not convincing to a lot of other researchers in regards of any changes in the muscle tone after the application [1,15,21-24].

Hislop & Perrine were the pioneers of the concept of isokinetic dynamometry in 1967 [25]. Since then it has become a popular method to measure muscle performance using some indices such as peak torque (PT) and total work (TW) in both research and clinical practice [26]. This dynamometer is a tool which allows the therapists and trainers to express the muscle power as a value [27]. Moreover, the isokinetic dynamometer allows for the measurement of muscle performance. Additionally, researchers can make protocols for muscle training and protocols to measure and produce muscle fatigue as well.

Muscle fatigue has been defined as any reduction in the force generation capacity of the total neuromuscular system regardless of the force required in any given situation [28]. Fatigue is a dynamic reversible process that contributed by a large array of physiological mechanisms. These mechanisms depend on the individual, tasks, environment, and the duration and the intensity of the effort [29].

Because of the shortage of the published studies on the effects of Kinesio Tape on the muscle fatigue, this study aims to investigate the effect of the inhibition technique of the Kinesio Tape on the triceps surae muscle after an isokinetic fatigue protocol. Having chosen specifically these muscles to be taped is based on the fact that the triceps surae muscle (gastrocnemius and soleus) account for approximately 80- 90% of the ankle's plantar flexion strength, including the 40- 43% contribution of the gastrocnemius itself [30]. The Gastrocnemius stiffness may limit the ankle's ROM and weaken the tonicity of the triceps surae, which may consequently affect the gate pattern [30]. The gastrocnemius muscle is considered to be at high risk for common strains for it is a bi-articular muscle crossing both the ankle and the knee joints, and is provided with a high density of (Type-II) fast twitch muscle fibers [31]. Correspondingly, the injuries of the gastrocnemius muscle are sorted among the most recurring injuries frequently occurring to the lower extremities (12%) [32].

Methods

A randomized controlled single blind pre-post experimental study has been conducted. Volunteers attended the laboratory at the University of Dammam on one occasion for approximately 2 hours. The testing procedures were identical for each participant in each group except for the application of the Kinesio Tape, and all data were collected and recorded by an examiner. Participants were asked to identify their current activity level according to the activities rating scale of Noyes et al. [33]. Leg dominance of each participant was determined by kicking a ball, stamping out a simulated fire, picking up a marble and tracing a shape with the lower-extremity [34]. The dominant leg was selected as the one preferred for 2 of the 3 tasks. Kinesio and Sham tape was applied on participants, and testing and fatigue protocol was done using Biodex dynamometer (Biodex Medical Systems, Shirley, New York).

Participants

Healthy male participants (N = 70) participant were recruited from among the staff and student population of the College of Applied Medical Sciences at the University of Dammam. Participants were divided into two groups, the experimental groups who received the therapeutic Kinesio tape, and the control group who received the sham Kinesio taping. The selection of the participants was based on the inclusion and exclusion criteria in Table 1. The average activity level of the included participants for each group as determined by the Noyes [33]. Sports-Activities Rating Scale (maximum score 100) was 61.86 ± 14.91 for the Kinesio taping group, and 62.14 ± 13.36 for the Sham Kinesio taping group Table 2. The right leg was dominant in 57 participants and the left in 13 participants. Participants' characteristics are summarized in Table 2. The institutional review board in the University of Dammam approved this study, (IRB NUMBER: 2014-04-320). Every participant received an information sheet containing full details of the study. After explaining the procedure to the participants, they were asked to sign an informed consent form before joining the study.

Table 1: Inclusion and exclusion criteria for the therapeutic Kinesio tape, and the control groups.

Inclusion Criteria
Aged between 18- 30 years. Good self-reported general heath.
Exclusion Criteria
Any history of severe lower limb injury or intervention (e.g. fracture, surgical intervention…). Any history of pain, trauma, or injury of the knee joint, triceps surae muscles or ankle joint 6 months prior to the study. Skin disease or self-reported hypersensitivity to tape application, including scar tissue in the acute phase.

Table 2: Participant's characteristics

Participant	Kinesio Taping Group			Sham Kinesio Taping Group		
	Mean	**Range**	**SD**	**Mean**	**Range**	**SD**
Age	20.23	18-27	2.5	19.45	18-22	1.3
Weight KG	71.01	45-104	17.08	72.09	44-116	19.36
Height CM	171.5	160-181	6.2	169.8	152-182	6.7
Level of Activity	61.86	40-85	14.91	62.14	40-85	13.36

Procedures

This study was carried out in the physical therapy research laboratories, College of Applied Medical Sciences, University of Dammam, Kingdom of Saudi Arabia. The recruitment of the participants was done through bulletin board advertisements which the researcher distributed all over the medical colleges campus in the university. In addition, social media advertisements and word of mouth were used to encourage the student to participate in this study. The distribution of the participants into each group was based on their choice. Each participant had the chance to choose a concealed envelop, which contains a number. Each number was belonging to either therapeutic Kinesio taping group or sham Kinesio taping group. The randomization was already done by using the research randomizer website www.randomizer.org. Participants who met the criteria were given a detailed explanation about the study objectives and methods. Furthermore, they were acquainted with the concept of the isokinetic fatigue protocol, as well as the Kinesio taping technique. The researcher then made sure that all participants had the chance to ask any questions regarding the study procedures.

Study Protocol

The installation and the calibration of the isokinetic dynamometer (Biodex dynamometer (Biodex Medical Systems, Shirley, New York) were done every day during the data collection. When participants presented themselves to the physical therapy research laboratory to participate in the study, researcher assigned them base on their numbers to the targeted group and handed them the information sheet, the informed consent form, and the data collection form. Moreover, participants completed the sport activity level sheet which was provided by Noyes et al. [33] After taking the anthropometric measurements, the dominant leg was then determined as the only test by asking participant to perform 3 tasks (kicking a ball, stamping out a simulated fire, picking up a marble and tracing a shape with the lower-extremity) [34]. Depending on the participant's assignment, the researcher applied either the Kinesio tape or the sham tape to the participant prior to starting the following sequences:

Therapeutic kinesio tape application

Triceps surae consists of two muscles: the gastrocnemius muscle and the soleus muscle. Each muscle was taped according to the manual provided by Dr. Kenzo Kase [4]. Taping the gastrocnemius muscle was done as follows:

A. The skin cleaned and shaved as necessary, and the triceps surae was actively stretched with the participant in the prone position, with the lower leg protruding off the bed.

B. In this stretched position, the length of tape of 5 cm width (KinesioTexGoldTape, USA) was then measured from the proximal gastrocnemius muscle insertion to the calcaneus bone, including an additional 4 cm to enable the tape to adhere properly to the heel.

This strip cut longitudinally from the proximal extreme of the tape to the triceps surae myotendinous junction, and placed directly on the skin without undue tension (100% of the maximum tape length) in three phases: 1) the tape was anchored at the heel with the ankle joint in a neutral position, 2) triceps surae was actively stretched and 3) the divided proximal end of the tape (the Y shape) was attached to the medial and lateral heads of the gastrocnemius muscles.

The taping sequences of the soleus muscle s as follows:

A. Another I shaped tape of the same tape brand was measured from the heel to the popliteal fold while the muscle is fully stretched.

B. The base of the tape was peeled off and anchored distally to the heel, with the ankle joint in a neutral position.

C. The participants are asked to fully dorsi-flex their ankles to stretch the muscle, and the rest of the "I" shape tape was applied to the lateral aspect of the gastrocnemius muscle to cover the soleus muscle. The final application of the tape is showed in Figure 1.

Figure 1: The application of therapeutic Kinesio taping on gastrocnemius and soleus muscles.

Sham kinesio tape application

The sham-taping protocol applied by placing three short strips of the same brand of tape onto the edges of the usual Kinesio taping application (heel, 12 cm), and the medial and lateral heads of the gastrocnemius muscles (5 cm). By this, the sham-taping was applied to the ineffective parts of the triceps surae muscle so that the discontinuity of taping was assumed to have no effect on muscle release [35] Figure 2.

Figure 2: Sham Kinesio tape application.

After application of the tape, participants were asked to warm up for 15 minutes. This involved using a treadmill (Biodex treadmill) for 5 minutes at a self-chosen speed, a stationary bicycle with absolutely no load for 5 minutes, and undertaken stretching exercise for the triceps surae muscles for 5 minutes. The stretching exercise involved asking the participant to face the wall, put their tested legs behind their bodies and lean forward with their hands on the wall until they felt a stretching in the calf area. They were asked to maintain this position for 30 seconds and repeat the maneuver 10 times. After completing the warm-up session, each participant rested for 5 minutes while the researcher familiarized them with the concept of the isokinetic measurement and what he was expecting them to do. The participant then sat on the isokinetic chair and the researcher tied them to the chair using 2 chest straps, one pelvic strap and one strap on the uninvolved thigh for fixing the participant onto the chair and eliminating any additional force from the hip muscles which may affect the calf muscle power as shown in Figure 3.

The fatigue protocol was performed using a Biodex dynamometer (Biodex Medical Systems, Shirley, New York). The reliability of this dynamometer has been shown to be high, with an intra-class correlation coefficient (ICC) of 0.99 for position, peak torque and velocity [36,37]. In addition, the reliability of isokinetic variables for assessing the muscle strength of the ankle dorsi-flexor (ICC of 0.77 to 0.93) and the ankle plantar flexor (ICC of 0.78 to 0.95) has been clearly reported in the literature [38].

Participants were positioned based on the manufacturer's guidelines for assessing strength testing for ankle dorsi-flexion and plantar-flexion. Concentric plantar-flexion was performed in a sitting position; with the isokinetic chair tilted to about 75 degrees, and the knee of the ipsilateral limb at 20˚-30˚ of flexion.

Figure 3: Participants position on the biodex dynamometer.

Once the participant was positioned on the biodex dynamometer, the range of motion of the ankle was set for the isokinetic trials, following a series of systematic steps. For additional familiarization to the isokinetic concept, each participant did 3 consecutive maximal plantar-flexion contractions with an angular velocity of 120°· s - 1 just to make the participants confident about what he is about to do. These first 3 repetitions were ruled out for the purposes of the study. After the familiarization session and prior to the fatigue protocol, participants were instructed to do 3 consecutive maximal force plantar flexion contractions. After completing these 3 contractions, the first peak torque and the total work were recorded. For the isokinetic fatigue protocol, the Biodex dynamometer was programmed to monitor 50 consecutive concentric plantar-flexion contractions at 60°· s - 1, with an active return of the ankle to the starting position at 300°· s - 1. A total of 50 contractions were selected since, in trials involving 100 such contractions, torque has been reported to remain relatively stable after 50 contractions [39]. The participants were encouraged to push as hard as possible and to complete the full range of motion by strong verbal encouragement being given throughout the test, in order to motivate them to develop maximal torque during each repetition [40]. After completion of the fatigue protocol, the fatigue index (FI) was calculated [41]. The fatigue index was computed according to the following equation:

FI= 100- {average performance of the last 3 reps/ average performance of the first 3 reps*100} [41].

Finally, the participants were asked to do the last 3 consecutive plantar flexion contractions at the same angular velocity and the second peak torque, and the total work was recorded by the dynamometer software.

During the isokinetic testing, the researcher provided the participant with a safety button which allowed the participant to terminate the test when he felt that it was too hard. However, because the targeted participants were normal individuals, nobody terminated any of the tests at any time.

Between the three measurement tests, each participant took one minute rest between the familiarization session and the first

session, one minute between the first session and the fatigue protocol session, and three minutes between the fatigue protocol session and the last measurement session.

Lastly, the researcher untied the participant from the isokinetic chair, thanked the participants for his participation in the study, and made sure that the participants did not experience any type of pain or muscle spasm after the tests.

Data Analysis

SPSS software version 17.0 was used to do all the statistical analysis. For baseline measurements, an independent t-test was used to ascertain that both groups were similar in terms of age, weight, height, and level of activity.

For additional confirmation that groups are somehow similar to each other, an independent t-test was also used to examine whether or not the muscle power which represented by the pre-peak torque and the pre-total work was similar in each group. So, the researcher compared both peak torque and total work before the fatigue protocol.

A dependent t-test was used to compare the peak torque and the total work before and after the fatigue protocol in the case of the sham Kinesio taping group. Then, the same test was used to examine the same variables in the therapeutic Kinesio taping group.

Finally, an independent t-test was used to compare and analyze differences between both groups in regard to the fatigue index. .

The criterion for statistical significance was set at p <.05, with a 95% confidence interval.

Results

Baseline charestristics and initials values of pre fatigue readings of peak torque and total work are shown in Table 3. no meaningful differences existed between groups at baseline. The mean of the age, height, wieght, and level of activity are, ≈ 20, ≈ 170, ≈ 70 and ≈ 62 respictively. Moreover the pre fatigue values of peak torque and total work are ≈ 61.7 and ≈ 98.7 respictively.

Sham Kinesio Tape group experienced a significant decrease of triceps surae muscle peak torque and total work after the fatigue protocol. The dependent t-test revealed that there was a significant difference (p = .000) of the pre-peak torque (60.2±21.9) and the post-peak torque (49.8 ±18.8). Additionally, a significant difference (p = .000) was found between pre total work (99.91±43.1) and post-total work (73.43±34.9). These reductions are presented in the Figure 4.

In contrast, therapeutic Kinesio Tape group did not experience significant decrease in the pre-mentioned readings after completing the fatigue protocol. The dependent t-test revealed no significant difference (p = .600) of the pre-peak torque (63.2±14.8.9) and the post-peak torque (62.2 ±14.1). Additionally, no significant difference (p = .193) was found between pre total work (97.4±26.8) and post-total work (91.7±27.3) as shown in Figure 5.

Regarding the fatigue index comparison between both group, The independent t-test confirmed that participants in the sham Kinesio taping group experienced more fatigue (49.16 ±17.54) than did participants in the other group (33.08 ±19.57), (p = 0.001). Figure 6 shows the fatigue index comparison between both study group.

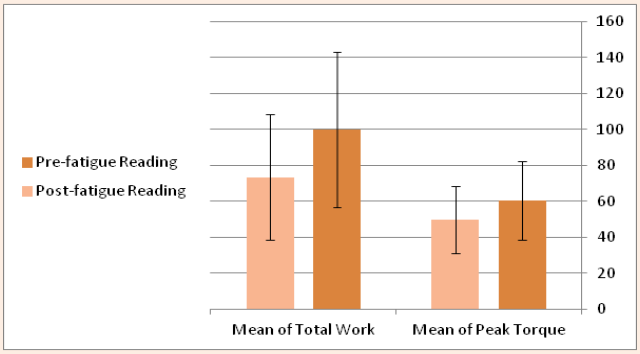

Figure 4: Differences in mean values of pre- and post- readings of peak torque and total work for the sham Kinesio Tape group.

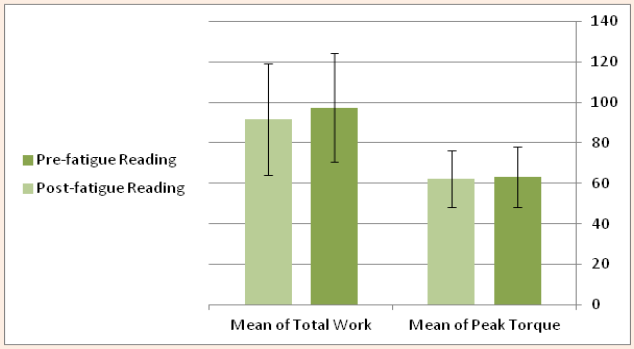

Figure 5: Mean value differences between pre-fatigue and post-readings in terms of peak torque and total work for the therapeutic Kinesio taping group.

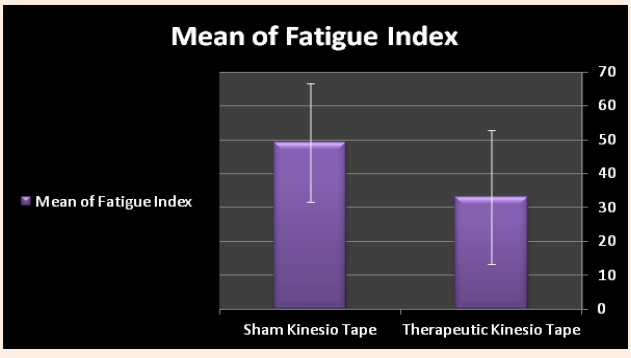

Figure 6: Mean values of fatigue index of both study groups.

Disscussion

This is the first study that invistigated the effect of KT on muscle fatigue induced by an isokinetic fatigue protocols. Our results came in consistency with Alvarez-Alvarez et al. [13] results and was inconsistence with the results of Yeung et al. [12]. Choosing isokinetic dynamometer for inducing the muscle fatigue was because of the ability of the muscle to move along the full ROM. Thus, the KT will produce the convolution that claimed to be necessary to produce the Kinesio Tape physiological effect. In Yeung et al. [12] study, they induced muscle fatigue by using an isometric fatigue prtotocol which measures the muscle power strength in fixed position which prevents dynamic contraction of the muscle. Therefore, the effect of the tape couldn't be obtained as there is no change in the length of the muscle. Unlike the previous study, this study shows that Kinesio Tape improved the recovery rate of the isokinetic peak torque after the fatigue protocol. This could be illustrated by the lifting effect of the skin that formed by the application of the KT which prevents fatigue by increasing the circulation beneath the targeted area [42,43]. Another possibility of improving the recovery rate for the therapeutic Kinesio tape group may be related to the cutaneous stimulation of the mechanoreceptors existed in the skin by the application of the tape. Kinesio Tape could stimulate the peripheral nerve and this stimulation reduces the motor neuron threshold [44], and promotes both muscle spindle reflex contraction of the applied muscle and the excitation of the motor cortex [45,46]. Although the results of this current study didn't show an immediate significant difference in calf muscle peak torque, yet, it showed propensity towards improvement instantly after 20 minutes of KT application (the mean of the peak torque in the Therapeutic Kinesio Tape (63.2) was higher than the Sham Kinesio Tape group (60.2)). This finding agreed with Fratocchi et al. [47] and Lumbroso et al. [18]. Fratocchi et al. [47] reported an increase in concentric and eccentric elbow flexor peak torque after application of KT on biceps bracii muscle. Similarly, Lumbroso et al. [18] investigated the effect of KT on hamstring and gastrocnemius muscle in regards of straight leg raising, knee extension angle, weight bearing ankle dorsiflexion, gastrocnemius, quadriceps and hamstring peak forces. They found significant increase of gastrocnemius peak force immediately after KT application; however for the hamstring peak force the difference was insignificant until 48 hours of KT application. This can be interpreted by the fact that KT has the ability to provide continuous tension to the skin, resulting in tension to the superficial until this tension arrived to the fascia since 30% of the muscle fibers inserted to the fascia as reported by Stecco et al. [48]. Additionally, it was proposed by O'Sullivan and Bird [49] that the effect of KT might be due to the unloading of the fascia.

Additionally, this study found that the application of the proper inhibition technique of the Kinesio Tape has led to delaying the triceps surae muscle fatigue. The inhibition technique of the KT is suggested to unloading the intrafusal muscle fibers, which sequentially reduces the Ia drive from the muscle spindle and, as a result, the drive to the motoneuronal pool [8]. Therefore, applying Kinesio Tape to the muscles will make the muscle more relaxed to generate similar peak torque and total work with significant decrease of the fatigue after completing the exercise prescribed. Furthermore, the motor units could be inhibited by the application of adhesive tape as well as the motor neuron threshold will be reduced [50].

In a study targeted the lower trapezius muscle, Alexander and colleagues found that application of adhesive tape over the lower trapezius could inhibit the H reflex of the trapezius muscle by 22% in regards to non taping condition. Five years later, they found that taping along the direction of the triceps surae muscle fibers reduces the amplitude of the H reflex which means, inhibiting this group of muscles as well [51]. This might also be due to the effect of KT on the skin mechanoreceptor.

One of the weaknesses of this study is the absence of a true control group, which would have provided a control for the reduction of the muscle power during the fatigue protocol. Another potential limitation of the study was the recruitment, since we only recruited healthy male participants. It is clear in the literature that male and female will response differently in regards of Kinesio tape application [17].

Moreover, the researcher who took the isokinetic measurements was not blinded in regards of the presence of the sham KT or the therapeutic KT. This may cause an expectancy bias, where the researcher beliefs cause him to unconsciously influence the participants to do more effort. Even though, efforts were made to standardize all the encouragement that has been given to the participants and the researcher tried to design the tests as uniform and objective as possible, there was a risk of measurement bias.

Future clinical trials with a high quality methodology should be performed to investigate the effects of the KT in athletic population and participants with musculoskeletal issues rather than studying healthy young individuals.

Conclusion

The results of the present study suggest that the proper application of the inhibition technique of the Kinesio tape does not immediately enhance the isokinetic peak torque. However, this taping method could delay the muscle fatigue and regenerate the initial isokinetic peak torque and total work after the fatigue protocol.

Key Points

Findings: Application of the inhibition technique of KT does not enhance the muscle power immediately but helps in delaying muscle fatigue and regenerate the initial power after the isokinetic fatigue protocol.

Implication: Clinicians and coaches may consider KT applications for their clients prior involving in exercises that may lead to muscle fatigue.

Caution: The results of this study are limited to young healthy individuals. Lack of athletes participants or symptomatic participants make it difficult to generalize the results of this study.

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Conflict of Interest

None.

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