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ORIGINAL RESEARCH

Kinesio Taping Increases Peak Torque of Quadriceps Muscle After Arthroscopic Meniscectomy, Double-Blinded RCT

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Purpose: This study was conducted to release the debate and examine the short-term impact of KT on the quadriceps muscle following arthroscopic surgery for partial meniscectomy.

Patients and Methods: As part of a double-blind, randomized controlled trial, 40 people who had an arthroscopic partial meniscectomy (APM) were randomly put into two groups, A and B. Group A received Kinesio tape (KT) for the superficial heads of the quadriceps muscle, while group B received placebo KTk. After 10 minutes of KT application, the peak torque of both groups was measured using a Biodex isokinetic dynamometer.

Results: Peak torque showed a significant increase in group A in comparison with group B during angular velocity 60◦/Sec. ($F(1, 130) = 58.9$, $p < 0.001$, $\eta 2 = 0.31$) and during angular velocity 180◦/Sec. ($F(1, 38) = 25.0$, $p < 0.001$, $\eta 2 = 0.40$).

Conclusion: After APM, individuals experienced an immediate and significant improvement in the quadriceps' peak torque following KT application to the Rectus femoris, Vastus medialis, and Vastus lateralis muscles from origin to insertion.

Keywords: quadriceps, kinesio tape, peak torque, arthroscopic partial meniscectomy

Introduction

The knee menisci are crescent-shaped wedges of fibrous cartilage on the medial and lateral aspects of the knee joint that expose smooth, lubricated tissue.[1] The menisci are critical to the function and long-term health of the knee joint,[2] providing shock absorption, load transmission, and joint stability.[3]

Meniscal injuries are increasing due to sports participation and advances in imaging techniques such as magnetic resonance imaging (MRI). A conservative estimate is 60 meniscal tears per 100,000, but the true incidence is likely underestimated.[4]

Over the past four decades, meniscal injury management has improved significantly. Previously, total meniscectomy was the gold standard, but the meniscus's weight-bearing function and potential degenerative changes led to the concept of meniscus preservation surgery. This approach has shown high success rates in terms of recovery time and functional outcomes.[5]

Arthroscopic partial meniscectomy (APM) is the most common orthopedic surgery globally, with approximately 500,000 performed annually in the USA, with 40% of patients under 45 years old.[6] APM is often used for degenerative

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meniscal tears (DMT), which are different from acute meniscal injuries that are often caused by sudden trauma and may also need APM.[7]

After APM, hamstring strength resolves quickly, but quadriceps strength is significantly reduced immediately, and weakness may persist. APM patients often return to daily activities weeks after surgery, despite quadriceps neuromuscular deficits.[8]

The quadriceps is critical for knee stability and dynamic function, particularly during the stance phase of gait to dampen and resist knee adduction moments, but prolonged strength deficits can lead to altered gait patterns, instability, and the risk of reinjury after APM, potentially accelerating joint degeneration.[9]

Six months after APM, quadriceps weakness is still evident. The EMG data show that the lack of muscular control at submaximal force output, but not at maximal force output, is more likely due to neurological defects (activation failure).[10]

Kinesio taping (KT) is recommended as a non-invasive treatment in the early postoperative and return-to-activity phases of knee surgery due to its convenience and potential to prevent injuries, improve movement patterns, and enhance athletic performance, unlike other therapeutic methods (eg, TENS, cold therapy, aquatic therapy, and manual therapy).[11,12]

KT has been shown to improve muscle function, increase lymphatic and vascular flow, reduce pain, correct joint malalignment, support joints, and improve proprioception.[13,14] Theories suggest that it stimulates superficial receptors (cutaneous) and alters motor unit recruitment, enhancing muscle activation and joint control.[11,15]

As APM changes sensory and motor components of the knee, KT may also be effective in increasing neuromuscular control of the knee and be a supportive treatment along with other rehabilitation interventions.[12,15]

Peak quadriceps strength is a useful indicator for promoting return to sport and preventing re-injury in injured athletes. The use of KT may improve muscular strength and joint stability in athletes with APM. Some studies suggest that the use of tape during explosive activity may be beneficial, while others have found it to be ineffective.[16]

Current systematic reviews reveal insufficient high-quality data supporting KT's use for musculoskeletal injury prevention or treatment, although recent studies have examined its effectiveness in promoting strength improvements.[17]

Few studies have examined how training with KT affects the peak torque and electrical activity of the femoral muscles in people with APM. Most of the studies have been conducted in healthy individuals and athletes.[18] This study aimed to investigate the short-term effects of KT on the maximal concentric and eccentric isokinetic strength of the quadriceps muscle in post-APM subjects.

Materials and Methods

Study Design

It was a double-blinded (patients, the data analyst, and the outcome evaluator were both unaware of group allocation) superiority RCT with two parallel groups. Ethical approval reference number REC-44/06/447 was acquired from the Standing Committee for Scientific Research at Jazan University (HAPO-10-Z-001), and each patient signed an informed consent form authorizing his or her participation. All steps of the evaluation and treatment of this research were carried out between February 2023 and April 2023. The study was registered prospectively at ClinicalTrials.gov under identifier NCT05715177 and conducted in compliance with the ethical principles outlined in the Declaration of Helsinki.

Participants

G Power 3.1.9.4 (Universitat Kiel, Germany) was employed to ascertain the sample size, assuming that the effect size is 0.5, a power of 80%, and a significance level of 0.05. The estimated sample size was 48. For the case of dropout, the sample size is increased by a 10% rate, and so the appropriate minimum sample size for this study was 53 subjects were assigned to be assessed for eligibility to share in the study; 13 subjects were excluded for the reasons in Figure 1, and thus 40 male patients after APM of any knee aged between 20 and 40 years old participated after signing a written informed consent form approved by the ethical committee of Jazan University. The subjects completed their hospital stay without suffering from any more knee injuries, only conducted APM,[9] indicated that maximum and explosive strength

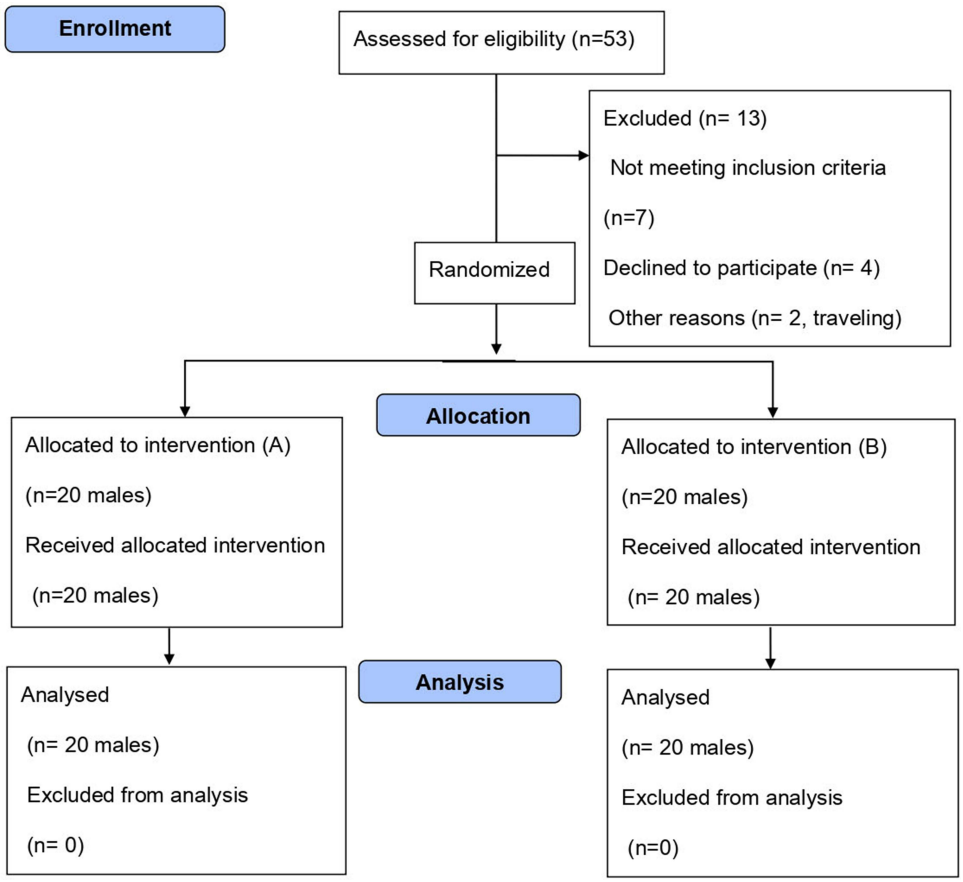

Figure 1 Consort flow chart of the participants with randomization.

deficits also occurred when compared to contralateral meniscal intact leg (healthy side),[19] and their body mass index ranged from 20–24.9 kg/m².

The participants were excluded if they had bilateral meniscal injuries, associated injuries to other knee structures, previous injury or surgery to either knee, cardiovascular, neurological, knee, or quadriceps problems restricting physical stress, a known allergy to adhesive material such as that used in the KT, or if they were smokers or heavy caffeine consumers.[19]

The participants were split into two equal-sized groups using the block randomization technique. Kinesio taping was applied to the superficial quadriceps femoris (QF) muscles (Vastus medialis (VM), Vastus lateralis (VL), and Rectus femoris (RF)) on 20 participants in Group A (the experimental group). 20 participants in Group B (the control group) got kinesio taping across the quadriceps as a placebo (Figure 1). Both groups experienced a similar distribution of leg dominance.

Measurements

Anthropometric measures, such as body mass index (BMI) and other measurements, such as weight (Wt.) and height (Ht.), were taken for all individuals during the initial meeting before the evaluation processes began.

Before beginning the evaluation method, each subject was instructed to use blades to remove the hair from their thigh. This was necessary to help the tape stick to the skin.[15]

Outcome Measure

Peak torque of quadriceps (QF): The peak torque of the limb that had APM was measured using the Biodex system 830–200 isokinetic dynamometer (Biodex Medical INC., Shirley, New York, USA) found in the biomechanics laboratory of the College of Applied Medical Sciences, Department of Physical Therapy, Jazan University.

Before the actual exercise regimen, the participants engaged in light-intensity warm-up routines like cycling and stretching for a duration of 5 minutes,[20] then the subjects sat on the chair of the Biodex system with their knees in 90° flexion, and resistance was given over the subject's ankle joint. The subjects were also instructed to clench their fists and hold their arms beside them. The back support was adjusted to allow a hip angle of 110° to the horizontal. The therapist positioned the straps on the subject's trunk, pelvis, and thigh while standing beside the tested limb.

Each subject was asked to concentrically extend the knee up to 0° extension and eccentrically flex the knee up to 90° (Figures 2 and 3). The protocol of muscle contraction was adjusted by the device to be concentric/ eccentric (con/ecc.), at speeds of 60 and 180°/sec., for 8 to 10 repetitions.[21]

Biofeedback was provided on a monitor, and the experimenter verbally encouraged subjects to use their muscle strength to the maximum. The muscle torque was measured for 10 repetitions at 60°/s and 180°/s, and the maximum peak torque value was calculated from the multiple measurements. Moreover, measurements were made while using the designated joint range. Once the measurements for a particular angular velocity were obtained, the participants took a 60-second break, as per Wong et al.[20] After the isokinetic pre-taping test, the subjects underwent 10 minutes of kinesiology taping for the rectus femoris, vastus medialis, and vastus lateralis. This was considered sufficient time for the inorganic phosphate (Pi) levels and force to fully recover following a maximal force contraction.[22] The subjects then underwent the same isokinetic test as before taping.

Application of Kinesio taping

Application for Group a (Figure 4)

Rectus femoris (RF): To increase tension in the tissue, each participant was instructed to lie supine with their thigh hanging off the table The medial tail of the "Y"-shaped Kinesio Tape was then applied to the anterior inferior iliac spine, and the lateral tail was positioned two to three fingerbreadths to the side of the medial tail. After slightly stretching the tape, it was placed on the superior edge of the patella and stabilized while being pulled proximally to further increase tissue tension. The hip and knee were then flexed with the foot flat on the table, and the KT was peeled off its paper liner

Figure 2 Starting position 90° knee flexion for measuring peak torque of (QF).

Figure 3 End position of the test, with full extension of the knee, for measuring peak torque (QF).

and temporarily applied to the skin. The tape's adhesive was activated through rubbing, and the other end of the tape was attached to the tibial tuberosity.[15,21]

Vastus Medialis (VM): The bottom portion of the intertrochanteric line was the location where Kinesio Tape was applied. The tape's unslit end was placed there, followed by temporarily holding the tape in place after peeling it from the release paper (liner). Next, the inner portion of the other end, which was slit, was applied to the pes anserinus, after which the knee was flexed. Finally, the outer portion of the other end, which was also slit, was applied to the patella.[15,21]

Vastus Lateralis (VL): To apply Kinesio tape, the greater trochanter of the femur was covered with a non-slit end of the tape. The examiner gently pulled the skin toward the patient's head while placing their hand on the greater trochanter of the femur. A portion of the end of the slit kinesio tape was then put on the superior side of the knee after the kinesio tape had been secured to the lateral aspect of the patella. After peeling the Kinesio tape from the release paper (liner), it was temporarily held in place. The lateral fibular head was then wrapped with Kinesio tape, with the lateral part of the other end cut into a slit. Following this, the knee was flexed, and the medial part of the KT's opposite end, which had been slit, was applied to the patella to envelop it with the taped.[15,21]

Application for Group B

Placebo tape was applied to each subject in group B by applying two I-shaped pieces of tape (Figure 5). One was placed around the upper thigh, and the other was placed around the lower thigh above the patella.[21]

Measurement of the tape was taken for all muscle heads from extension position of the knee, then during the application technique of taping the knee joint was flexed to about 90 ° which stretch the tape about 20% to 25% to put tension on the tissue.[23]

Statistical Analysis

Repeated measures ANOVA's design was performed to evaluate the size effect of kinesio taping on peak torque within groups (time: pre-test, post-test), between groups (control and experiment groups), and target angular velocity (60°, 180°/Sec.), a 2 × 2×2 (time vs group vs angular velocity). The assumption for the normality of the score distribution was tested using the Kolmogorov-Simonov test. The unpaired *T*-test was conducted to evaluate the differences in means of the

Figure 4 Taping modes of quadriceps heads (RF, VM, VL).

Figure 5 Placebo taping mode.

demographic information between the two groups at baseline. All statistical analyses were conducted with SPSS for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P < 0.05$.

Results

Forty participants (20×2 groups) completed the study. The following Table 1 illustrates the characteristics of the participants within the experiment (A) and control (B) groups.

The results in Table 1 revealed that overall, the mean age was 27.7 ± 4.9 years with an average body mass index (BMI) 23.6 ± 1.0. The number of involved participants in the study group was 20, the same as in the control group.

The overall descriptive statistics are shown in Table 2. The differences are given as mean values and standard deviations between groups at baseline and after taping according to angular options in muscle peak torque.

Interaction Effect of Intervention Group × Pre- and Post-Tape Application (at Velocity Angle 60)

The results in table x3 show that there was a significant interaction between intervention groups (control vs experiment) and application factor (before and after tap application at velocity angle 60 degree), F (1, 38) = 6.2, p =0.017, η2 =0.14. The effect size (Partial Eta Squared η^2) here is considered moderate and suggests that approximately 14% of the variance in the dependent variable (peak torque) can be attributed to the interaction between the intervention groups and the difference between pre-test and post-test measurements for the experimental condition. Overall, it shows that by ignoring the angle velocity angle of 180°/sec, the peak torque amount in the experiment group increased after taping (Figure 6).

Table 1 Basic Characteristics of the Subjects Involved in the Study

Variable	Control N=20 (M±SD)	Experiment N=20 (M±SD)	P-value
Age	27.0 ± 4.0	28.2 ± 5.8	0.853
Weight	71.5 ± 4.0	71.4 ± 4.3	0.940
Height	1.70 ± 0.03	1.73 ± 0.04	0.218
Body Mass Index	23.5 ± 1.2	23.8 ± 0.7	0.350

Notes: P value, significance level; M±SD, mean ± standard deviation; n, number.

Table 2 Changes in the Peak Torque Before and After Kinesiology Tape Application in Both Study Groups According to Velocity Angle and Time Tap Application

Taping	Velocity Angle	Control (M±SD)	Experiment (M±SD)	Total (M±SD)	Over all
Pre-Taping	60°/sec	74.3 ± 10.4	70.3 ± 8.0	72.3 ± 9.2	68.85 ±9.7
	180°/sec	61.1 ± 12.6	56.8 ± 6.5	59.0 ± 9.6	
Post Taping	60°/sec	57.7 ± 3.0	74.1 ± 10.9	65.9 ± 7.0	64.55 ±9.9
	180°/sec	59.0 ± 7.8	60.1 ± 11.2	59.6 ± 9.5	
Over all		63.0 ± 8.5	65.3 ± 9.2	64.2 ± 8.8	

Notes: M±SD, mean ± standard deviation.

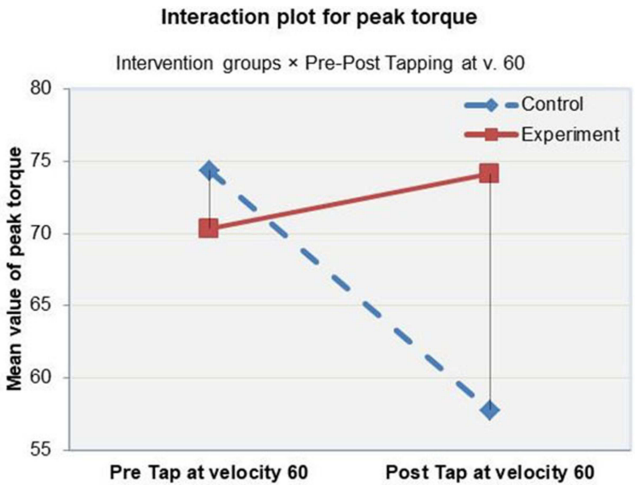

Figure 6 The amount of peak torque between groups and the interaction between groups before and after the application of taping at a velocity angle of 60.

Interaction Effect of Intervention Group × Pre- and Post-Tape Application (at Velocity Angle 180)

The interaction between control and experiment groups and the velocity angles 180 showed that these groups change statistically significantly at different rates according to the velocity angles, $F(1, 38) = 25.0$, $p < 0.001$, $\eta 2 = 0.40$ (Table 3). The effect size (partial eta-squared) of 40% is considered large and suggests a large interaction effect of the intervention group and "pre-post tap-app v180" factor on peak torque, and the statistically significant p-value indicates that this effect is unlikely to have occurred by chance. That means, in summary, that by ignoring the time of tape application, the torque force amount in the experiment group was increased, so the tape application was effective in increasing the peak torque force (see Figure 7).

Interaction Effect of Intervention Group × Angle × Pre- and Post-Tape Application

There was also a significant three-way interaction between intervention group, angle, and time, $F (1, 38) = 12.7$, $p = 0.001$, $\eta 2 = 0.25$. The effect size (partial eta-squared) of 25% for this main interaction effect suggests a large effect in the peak

Table 3 A Three-Way Mixed ANOVA for Evaluating the Changes in the Peak Torque Force in the Data with Three Main Factors (Pre-Post Tape Application), Intervention Groups, and Velocity Angle and Their Interactions

Source	Type III Sum of Squares	Df	Mean Square	F	P-value	Partial Eta Squared (effect size)
Pre-post tape v60	3740.5	1	3740.5	42.3	0.000	0.53
Intervention-Gr × Pre-post tape v60	552.0	1	552.0	6.2	0.017	0.14
Error (Pre-post tape v60)	3361.1	38	88.5			
Pre-post tape v180	282.6	1	282.6	4.0	0.054	0.09
Intervention-Gr × Pre-post tape v180	1781.1	1	1781.1	25.0	0.000	0.40
Error (Pre-post tape v180)	2706.9	38	71.2			
Pre-post tape v60 × Pre-post tape v180	542.1	1	542.1	13.3	0.001	0.26
Intervention-Gr × Pre-post tape v60 × Pre-post tape v180 ×	517.4	1	517.4	12.7	0.001	0.25

Notes: Pre-post tape v60/v180, pre- and post-tap application under velocity angle 60/180; Intervention-Gr: Intervention-Groups; df, degree of freedom; F, F-test; P value, significance level.

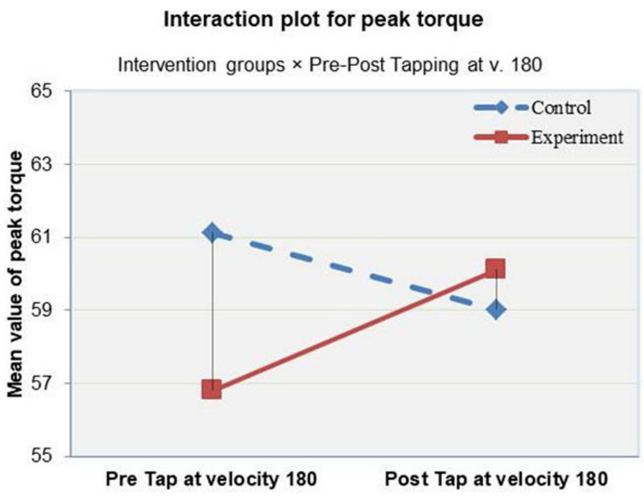

Figure 7 The amount of torque force peak between groups in interaction with before and after application of taping at a velocity angle of 180.

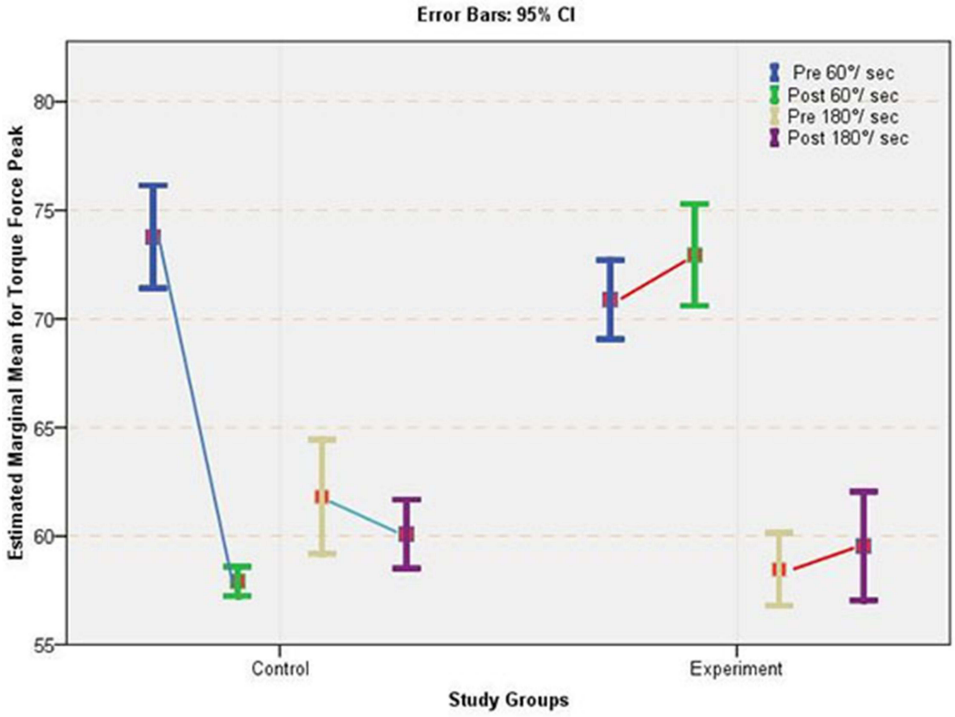

Figure 8 The differences in torque force peak between groups in interaction with time and angle.

torque, which can be accounted for by the difference between the intervention groups and pre-test and post-test measurements for the experimental condition (tap-app v60° and V180°), demonstrating that the amount of difference in torque between taping application time (whether before or after) and angular velocity (whether the velocity angle was 60 or 180) was significantly different in the control and experiment groups (Figure 8).

Discussion

The results of the study showed that kinesio taping the muscle heads from origin to insertion improved the peak torque of the quadriceps muscle in individuals who had undergone arthroscopic partial meniscectomy (APM) surgery. The results demonstrated that the kinesio taping had a moderate and large effect size on the peak torque of the quadriceps muscle at

velocities of 60° and 180°, respectively. We attributed this to an interaction between the groups and the difference between the experimental condition's pre-test and post-test measurements. The overall result showed that the peak torque increased after the application of taping.

The findings underscore the significance of considering the interactions between the intervention group, the timing of the kinesio taping application, and the velocity angle when examining changes in peak torque force. The results show that the specific conditions of application, such as the angle and timing, determine the effectiveness of the intervention on peak torque force. Researchers and practitioners should incorporate these factors into their designs of interventions aimed at improving peak torque force.

The cutaneous fusimotor reflex hypothesis, which contends that several types of tactile stimuli, including touch and vibration, can activate gamma motor reflexes and increase muscle strength, may contribute to this phenomenon.[24] This is in accordance with Yeung et al's findings that stretchy kinesiology tape could stretch mechanoreceptors, activate muscle spindles, and enhance muscular contraction, according to their study on the vastus medialis obliques.[25]

By reducing the effect of Ia afferent input through tactile stimulation, which can promote muscular contraction, kinesio taping may increase muscle strength. Konishi and Kiele, who also held this opinion, asserted that using KT increased quadriceps strength due to the tactile stimulation's ability to reduce Ia inhibitory afferent input. This then stimulates the contraction of muscles and gamma motor neurons, increasing the transmission of force.[19,26]

Yeung et al found that KT improved maximum torque output as compared to an inhibitory technique in healthy adults performing isokinetic knee extension. Although their study involved healthy participants, their findings are in line with current research, which focused on subjects who had undergone APM surgery. Yeung et al explained that the primary mechanism of action for KT is the facilitation of the muscle spindle reflex through the recoil effect and that dynamic movement is required to activate the mechanoreceptors and facilitate muscle contraction, which may not be achieved with isometric exercises.[27]

All the previous discussions have emphasized the absence of positive outcomes in muscle peak torque in the control group subjected to placebo taping. It is believed that this could be due to the direction of the taping application, which was vertical to the muscle fibers and fascia orientation, unlike the experimental group, where it was parallel to the muscle fascia direction. This aligns with the views of Vithoulka et al, who proposed applying the tape according to the fascia direction to enhance peak torque.[21]

To increase muscular torque, Choi and Lee (2018) advised wrapping kinesiology tape across the quadriceps' rectus femoris, vastus medialis, and vastus lateralis. After using the tape in the current investigation,[23] the experimental group showed improved muscle torque, whereas the control group did not.

Thus, in the current study, increased knee muscle strength may be presumably because of decreased knee pain sensation, which was noted but not measured as one of the variables of this study. The mechanisms behind the pain relief effects of KT applications remain poorly understood.[28] Various theories have been proposed explaining mechanisms of kinesio taping for pain relief, such as skin-elevating effects when pressure on subcutaneous nociceptors is decreased or decongestive properties, inhibition of the transmission of nociceptive signals, or stimulation of descending inhibitory mechanisms from the higher centers of the brain are improved.[19,29]

Numerous earlier investigations found no appreciable increase in quadriceps peak torque with kinesio taping.[16,20,30–33] In these studies, only the rectus femoris, one of the four quadriceps muscles, was treated with kinesiology tape. In contrast, in the present investigation, kinesiology tape was applied to the rectus femoris, vastus medialis, and vastus lateralis, following the approach of Han and Lee (2014). This difference in application may account for the notable variation in muscle torque seen with KT application.[34] In addition, this study has other strengths, which include the sample size and the timeframe for assessing the immediate outcome. Furthermore, the use of a clinically applicable method to improve quadriceps strength following APM and the objective method for assessing muscle peak torque are noteworthy. Conversely, the study's limitations include the inability to assess the long-term effects of KT application following APM. Long-term effects need to be studied.

Conclusion

Kinesio taping the rectus femoris, vastus medialis, and vastus lateralis from origin to insertion resulted in immediate and significant improvements in the peak torque of the quadriceps muscle in patients who had undergone arthroscopic partial meniscectomy. A significant main interaction effect was observed between the groups, angle, and pre-post taping application (25% effect size). This effect was found to be significantly different between the experimental and control groups.

Data Sharing Statement

The dataset of the research study is not publicly available. However, it can be obtained upon request from the main author (Dr. Mohamed M. Ahmed, email: mmahmed@jazanu.edu.sa).

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Disclosure

The authors report no conflicts of interest in this work.

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