Article

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Physiological, kinematic, and electromyographic responses to kinesiology-type patella tape in elite cyclists

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CONFLICT OF INTEREST

None.

FINANCIAL DISCLOSURE

None.

ABSTRACT

Kinesiology-type tape (KTT) has become popular in sports for injury prevention, rehabilitation, and performance enhancement. Many cyclists use patella KTT; however, its benefits remain unclear, especially in uninjured elite cyclists. We used an integrated approach to investigate acute physiological, kinematic, and electromyographic responses to patella KTT in twelve national-level male cyclists. Cyclists completed four, 4-minute submaximal efforts on an ergometer at 100 and 200 W with and without patella KTT. Economy, energy cost, oxygen cost, heart rate, efficiency, 3D kinematics, and lower-body electromyography signals were collected over the last minute of each effort. Comfort levels and perceived change in knee stability and performance with KTT were recorded.
The effects of KTT were either unclear, non-significant, or clearly trivial on all collected physiological and kinematic measures. KTT significantly, clearly, and meaningfully enhanced *vastus medialis* peak, mean, and integrated electromyographic signals, and *vastus medialis*-to-*lateralis* activation. Electromyographic measures from *biceps femoris* and *biceps*-to-*rectus femoris* activation ratio decreased in either a significant or clinically meaningful manner. Despite most cyclists perceiving KTT as comfortable, increasing stability, and improving performance, the intervention exerted no considerable effects on all physiological and kinematic measures. KTT did alter neuromuscular recruitment, which has potential implications for injury prevention.

INTRODUCTION

Many health professionals, athletes, and coaches use kinesiology-type tape (KTT), with the intent to manage musculoskeletal sport injuries; however, growing evidence suggests no additional benefit from KTT application compared to placebo taping or active control treatment methods when managing musculoskeletal conditions (Ouyang et al., 2018, Williams et al., 2012). On the other hand, several beneficial effects from KTT application have been reported, including enhancement in muscle activation (Gilleard et al., 1998); improved biomechanics, joint, and patella alignment (Lyman et al., 2017, Merino-Marban et al., 2013); and decreased pain (Bockrath et al., 1993, Merino-Marban et al., 2013). It is worth noting, however, that many studies report no effect from KTT on these measures (Halski et al., 2015) or athletic performance (Lins et al., 2013, Reneker et al., 2018). Underlying reasons for such contrasting scientific findings likely include the varied application methods, differences in the mechanical properties of KTT across brands (Matheus et al., 2017), targeted population, and individuals' perceived benefits of KTT with a potential for placebo effect (Mak et al., 2018) .

Cycling is a popular recreational and competitive sporting activity worldwide, and a common exercise modality used during rehabilitation. At an elite level, athletes and coaches continually seek for ways to improve performance through marginal gains and prevent the occurrence of injuries. KTT is routinely used by coaches and athletes as an ergogenic aid (Reneker et al., 2018), with various forms of taping employed to prevent injury occurrence or recurrence (Zech and Wellmann, 2017). Given that up to 94% of professional cyclists suffer from at least one overuse injury annually (Silberman, 2013), the visible increase in use of KTT amongst elite cyclists for prophylactic purposes is not surprising.

Taping or bracing are frequently used to alleviate patellofemoral pain (PFP) symptoms and can impact knee motion during cycling (Theobald et al., 2012). Non-specific KTT application has been shown to be as effective as specific application for reducing pain and inducing significant changes in lower-body cycling biomechanics in a symptomatic population group (Theobald et al., 2014). However, any potential positive effect of taping on energy cost of cycling, neuromuscular recruitment patterns, and performance of asymptomatic high-level cyclists has not been examined, despite the visibly increased prevalence of use in the cycling community and KTT marketing campaigns.

Using an integrated approach, our aim was therefore to investigate the acute physiological, kinematic, and electromyographic outcomes in response to applying KTT to the knee of elite cyclists. As perceptions may influence outcomes of interventions, individual perceptions were also assessed. We hypothesised that taping would be accompanied by changes in muscle recruitment patterns, cycling economy and efficiency, and perceived stability that have the potential to modulate cycling performance.

MATERIALS & METHODS

Participants

All male cyclists of the National Cycling Team training at the National Sports Institute for Malaysia (n = 12) were invited and accepted to participate in this study. These 12 national cyclists (mean ± standard deviation (SD): age, 21.7 ± 2.8 years; body mass, 65.6 ± 5.4 kg; and height, 172.7 ± 3.4 cm) with at least four years of training experience provided written informed consent to participate in this study, which adhered to The Code of Ethics of the World Medical Association (*Declaration of Helsinki*) and was approved by our Institutional Ethical Review Board (ISNRP 29/2015). Inclusion criteria were cyclists training at the National Sports Institute of Malaysia for the National Cycling Team, good self-reported general health, and at least 18 years of age. Cyclists with current or recent (< 1 month) musculoskeletal injuries, joint pathologies, or medical contraindications to physical exertion were excluded.

Design

All cyclists attended 3 sessions at the biomechanics laboratory of the National Sports Institute of Malaysia, one week apart. The first two weeks were familiarization sessions and the third week was used to investigate the acute effects of KTT application through a repeated-measures randomized experimental study design.

Given that ergometer versus outdoor cycling can affect cycling physiological measures (Bertucci et al., 2012) and pedalling biomechanics (Bertucci et al., 2007), cyclists brought their road bikes to the laboratory the first week of testing. Bike setup parameters were recorded and employed to individualize setup on a Lode cycling ergometer (Excalibur Sport, Lode B.V., Groningen, Netherlands), with all cyclists using their habitual cleats. The final ergometer setup was recorded and used across the three weeks. Baseline demographics, including leg dominance (self-perceived stronger cycling side), were recorded. Body mass (kg) was measured weekly and subsequently used to calculate relative physiological variables.

Cyclists began all sessions with a 2-min cycling warm-up on the ergometer after being set-up with the monitoring equipment. Cyclists then performed a submaximal 4-minute cycling effort at 100 W, followed immediately by a second submaximal 4-minute cycling effort at 200 W. The efforts were completed without KTT during the familiarization weeks, and twice on the third week: once with and once without KTT. The no tape (NT) and KTT conditions were completed in a block-randomized order and separated by a 5-minute passive seated rest. Thus, all cyclists completed four 4-minute efforts: NT 100 W, NT 200 W, KTT 100 W, and KTT 200 W. The powers of 100 and 200 W were selected to ensure that cycling efforts were below the anaerobic threshold and to compute delta efficiency (Coyle et al., 1992) (see **Physiology**). Furthermore, the application of patella KTT at these powers has been shown to alter lower-body cycling biomechanics in previous studies (Theobald et al., 2014), with these power levels set alongside the National Cycling Team of Malaysia to inform their practice and use of KTT application in longer steady-state riding situations.

Taping method

The taping application we used was based on a method previously reported to induce changes in cycling biomechanics within the power ranges here examined (Theobald et al., 2012, Theobald et al., 2014). With cyclists seated on the ergometer with the leg at the bottom of their power stroke , a strip of KTT (RockTape™, RockTape Inc., California) of length equal to 50% of individual knee circumference was applied on to the centre of the patella with light tension (approximately 25% of stretch to the tape). The medial and lateral tape edges were aligned with the medial and lateral knee-joint lines (**Figure 1)**. The same experienced physiotherapist applied the tape to all cyclists. This simple KTT method (i.e., across the patella) was selected given its ease-of-use and findings from previous studies indicating that such a method impacts cycling biomechanics in a manner that is comparable to that of a more intricate KTT application method (Theobald et al., 2014). Given the minimalist KTT method applied, a "placebo" taping method was not implemented.

*****Insert Figure 1*****

Physiology

Oxygen consumption (VO_2), carbon dioxide output (VCO_2), and heart rate were monitored throughout the 4-minute experimental efforts using a calibrated K5 wearable metabolic technology system (COSMED, Rome, Italy). All physiological measures were averaged over the last minute where steady state was observed. VO_2 was used to determine steady-state relative oxygen cost (mL/kg/km) and absolute cycling economy (W/L/min). From the VO_2 and CO_2 data, the relative energy cost of efforts (kcal/kg/km) was estimated using the energy expenditure equations described by Jeukendrup and Wallis (2005). Gross efficiency (%) and delta efficiency (%) were calculated as suggested by Coyle et al. (1992) using the ratio of work accomplished (watts converted to kcal/min) to absolute energy cost (kcal/min) for gross efficiency, and the reciprocal of the slope that describes the relationship between the absolute energy cost and work accomplished for delta efficiency.

Kinematics

Lower-body, trunk, and pelvis movements were captured in 3D during the last minute of each 4-minute cycling effort at 300 Hz using 10 Oqus 300 infrared cameras and the Qualisys Track Manager Software version 2.12 (Qualisys AB, Gothenburg, Sweden). Forty-six retro-reflective markers (12 mm in diameter) were affixed to the skin, clothes, and shoes of cyclists based on the Calibrated Anatomical System Technique (Cappozzo et al., 1997) and following established guidelines (Grood and Suntay, 1983). All 46 markers were used for static calibration; whereas 14 markers were removed for the cycling efforts (**Figure 2**).

*****Insert Figure 2*****

An 8-segment biomechanical model with 6 degrees of freedom at each joint was constructed in Visual3D Professional™ Software version 5.02.30 (C-Motion Inc., Germantown, MD, USA), with the local coordinates of the trunk, pelvis, thighs, shanks, and feet derived from the static calibration and the pelvis used to define hip-joint centres (Bell et al., 1989). Prior to each session, the measurement volume was calibrated using a 750-mm wand and L-frame that defined the Cartesian origin of the laboratory. Cyclists were then requested to sit on the saddle of the ergometer, with legs hanging to the side, and remain motionless to allow static calibration.

Electromyography

The electromyography (EMG) signals from the following four muscles were recorded on both the dominant and non-dominant sides: *vastus medialis* (VM), *vastus lateralis* (VL), *rectus femoris* (RF) and *biceps femoris* (BF). Signals were recorded using Noraxon's Dual EMG surface Ag/AgCl electrodes (17.5 mm inter-electrode distance), wireless EMG sensors, and Desktop DTS data logger (Noraxon USA Inc., Scottsdale, AZ). EMG data were sampled at 1500 Hz, low-pass filtered at 500 Hz, and digitally integrated through the

Qualisys Track Manager Software. Skin preparation and electrode positioning followed the Surface EMG for Noninvasive Assessment of Muscle (Hermens et al., 2000), International Society of Electrophysiology and Kinesiology (Merletti and di Torino, 1999), and published protocols (Gilleard et al., 1998). Cyclists completed a few cycling revolutions before experimentation to allow visual inspection of EMG signal quality. Sensors were checked and reapplied if artefacts were observed.

Perception

Perceived change in knee stability and performance with KTT compared to NT was assessed at the end of the experimental session using a 5-point Likert (1932) Scale from negative (1) to positive (5) perception, with the mid-point value representing no change (3). Comfort level of KTT was also assessed using a similar method. Anchor points ranged from very uncomfortable (1), much less stable (1), and much worse (1) to very comfortable (5), much more stable (5), and much better (5) for comfort, knee stability, and performance, respectively.

Data processing

Kinematic and EMG data were exported to the C3D format and processed in Visual 3D. Marker data were filtered using a 4^{th} order zero-lag 15 Hz Butterworth bidirectional filter. Kinematic parameters were then calculated using rigid-body analysis and Euler angles obtained from the static calibration. Hip, knee, and ankle angles in the sagittal (flexion-extension), coronal (adduction-abduction), and transverse (internal-external rotation) planes were calculated using an x-y-z Cardan sequence equivalent to the Joint Coordinate System (Grood and Suntay, 1983), with the pelvis angles in the sagittal (anterior-posterior), coronal (dominant, non-dominant obliquity), and transverse (dominant, non-dominant rotation) planes defined relative to the laboratory. Trunk angles in the sagittal (flexion-extension), coronal (dominant, non-dominant lateral flexion), and transverse (dominant, non-dominant rotation) planes were also defined in relation to the laboratory coordinates. Data were divided into movement cycles and time-normalized based on maximal knee flexion events. Ensemble-average kinematic curves were generated for each participant and cycling effort, and range of motion (ROM) values extracted.

EMG signal data were zeroed to remove any baseline offset and a 20-Hz high-pass filter applied to remove movement artefacts. Signals were subsequently rectified and linear envelopes generated by smoothing the data using a low-pass, 4^{th} order, zero-lag 15 Hz Butterworth filter. The linear envelope for each muscle was then normalized to the highest observed signal across all four conditions examined (% max). Similar to the kinematic data, ensemble-average EMG signal curves time normalized to maximal knee flexion events were generated from which mean and peak EMG signal values were extracted. An integrated EMG (iEMG) signal was also generated by integrating the linear envelop from the start to the end of each movement cycle, which was then normalized to the maximal observed iEMG across all four efforts (% max).

Statistical analysis

Mean and SD values were computed for all parameters for both the 100 and 200 W efforts and dominant and non-dominant sides. Changes in mean (Δ_{mean}) and standardized effect sizes (ES) were computed to quantify the acute effect of KTT; with ES considered small, moderate, large, and very large when reaching thresholds of 0.2, 0.6, 1.2, 2.0, and trivial when < 0.2 (Smith and Hopkins, 2011). An effect was deemed ‘clear’ when its 90% confidence limit did not overlap the thresholds for small positive and small negative effects (i.e., 5%); and ‘likely’ to be clinically meaningful when its probability exceeded 75% (Smith and Hopkins, 2011).

Paired *t*-tests were used to investigate differences between the tape and no-tape condition for the measures of interest, with the threshold for statistical significance set at $P \leq 0.05$. All data were analysed using customized statistical spreadsheets (Microsoft Excel 2013, Microsoft Corp, Redmond WA, USA).

RESULTS

Physiology

KTT had clear and trivial effects on oxygen cost and energy cost measures at 200 W that did not reach statistical significance. The effect of KTT on all other physiological parameters was unclear or unlikely, and not statistically significant (**Table 1**).

*****Insert Table 1*****

Kinematics

The clear and likely effects of KTT on ROM values at 100 W (**Table 2**) and 200 W (**Table 3**) were trivial, except for the mean ankle ROM in the transverse plane at 100 W on the dominant side, where a small non-significant increase was noted (ES, 0.35; *P*, 0.097; **Table 2**). In all other cases, the effect of KTT was unclear or unlikely, and not statistically significant.

*****Insert Table 2*****

*****Insert Table 3*****

Electromyography

The effect of KTT on certain VM, VM-to-VL ratio, BF, and RF-to-BF ratio measures were clear, likely, and significant at 100 W (**Table 4**) and 200 W (**Table 5**). Changes primarily affected the efforts performed at 100 W.

At 100 W, the effect of KTT on the non-dominant side was clear, likely, and significant for increasing VM peak (ES, 1.35; *P*, 0.044), and decreasing the RF-to-BF ratio peak (ES, -0.42; *P*, 0.021) and mean (ES, -0.62; *P*, 0.016) measures. There was also clear and likely non-significant increases in VM iEMG (ES, 0.72; *P*, 0.128); and VM-to-VL ratio peak (ES, 2.20; *P*, 0.118), iEMG (ES, 1.26; *P*, 0.097), and mean (ES, 1.21; *P*, 0.08) measures.

At 100 W, the effect of KTT on the dominant side was clear, likely, and significant for increasing VM iEMG (ES, 0.98; *P*, 0.024) and mean (ES, 0.95; *P*, 0.030); increasing VM-to-VL ratio peak (ES, 2.19; *P*, 0.009), iEMG (ES, 1.63; *P*, 0.020), and mean (ES, 1.21; *P*, 0.029); and decreasing BF mean (ES, -0.36; *P*, 0.047) measures. There was also a clear and likely non-significant increase in VM peak (ES, 0.87; *P*, 0.056); and decrease in RF peak (ES, -0.39; *P*, 0.135) and mean (ES, -0.51; *P*, 0.137) measures.

*****Insert Table 4*****

At 200 W, the effect of KTT on the non-dominant side was clear, likely, and significant for increasing VM iEMG (ES, 1.04; *P*, 0.014). There was also a clear and likely non-significant increase in VM peak (ES, 0.92; *P*, 0.122) and mean (ES, 0.92; *P*, 0.088); increase in VM-to-VL ratio peak (ES, 1.41; *P*, 0.157), iEMG (ES, 0.88; *P*, 0.124), and mean (ES, 2.07; *P*, 0.098); and decrease in BF mean (ES, -0.39; *P*, 0.194). At 200 W, there was a clear and likely non-significant effect of KTT on decreasing peak BF (ES, -0.69; *P*, 0.077) measures.

*****Insert Table 5*****

Perception

Most cyclists perceived KTT as being comfortable, providing additional stability to the knee, and enhancing performance (**Figure 3**). However, three cyclists felt that KTT was uncomfortable, with one cyclist feeling more unstable with KTT.

*****Insert Figure 3*****

DISCUSSION

Despite most cyclists perceiving enhanced performance and knee stability with patella KTT; the effects of the intervention were either unclear, non-significant, or clearly trivial for all physiological and kinematic measures, except for a small non-significant increase in ankle ROM on the dominant side in the transverse plane at 100 W. KTT affected the EMG-determined muscle activation patterns the most, notably increasing VM and VM-to-VL ratio measures at both powers; and decreasing BF and RF-to-BF ratio measures. Overall, our findings indicate a potential for patella KTT to alter the neuromuscular recruitment patterns of elite cyclists with no current musculoskeletal injury at low powers, which could have implications in the prevention of overuse injuries.

Physiology

Cycling biomechanics and neuromuscular function can alter energy cost, oxygen cost, and cycling efficiency. For instance, cycling in a more aerodynamic than upright position can increase oxygen cost by 1.5% (Gnehm et al., 1997). This increase is speculated to result in part from a shift in mean hip-joint angles towards greater flexion, which alters the operating points of the hip- and knee-joint muscles on the force-velocity and force-length curves, as well as an increase in hip adductor activation to prevent out-of-plane motion in extreme hip flexion. The biomechanical and neuromuscular differences associated with changing cycling positions from aerodynamic to upright are inherently much larger than those potentially resulting from KTT application, especially proximally at the trunk, pelvis, and hip (Dorel et al., 2009). It is likely that the neuromuscular changes observed here in VM, VM-to-VL ratio, BF, and RF-to-BF ratio measures with KTT were not sufficient to cause significant or clear alterations in the physiological parameters monitored.

Kinematics and muscle activation

Ideally, the legs should act as pistons during cycling (Sanner and O'Halloran, 2000), with lower-body motion mainly directed upwards and downwards, and cyclists in a saddle position that allows knee extension with minimal valgus angulation. Most studies addressing lower-body kinematics during cycling have focused on sagittal plane motion, with our sagittal ROM values agreeing with those typically reported (Bini et al., 2011). Although a certain amount of ‘out-of-plane’ motion is anticipated, lower-body misalignment and excessive out-of-plane motion are reported to contribute to musculoskeletal injuries in cyclists (Bini et al., 2011, Gregor and Wheeler, 1994). One of the proposed benefits of KTT is to assist in joint alignment through improvements in proprioception, which in turn can improve movement patterns and cycling efficiency. Hence, we anticipated less out-of-plane motion at the knee with KTT; however, such a reduction was not evident.

Previous studies have shown that patellar taping can affect movement patterns in both healthy and symptomatic individuals (Theobald et al., 2014), as well as muscle recruitment of VM (Gilleard et al., 1998), VL (Gilleard et al., 1998), and RF (Konishi, 2013). These changes in neuromuscular function are suggested to result from the tactile stimulation of the skin (Konishi, 2013), rather than by the actual tape configuration or alterations in patellar positioning (Bockrath et al., 1993). Conversely, several other studies have observed no effect from therapeutic taping on neuromuscular function (Halski et al., 2015, Lins et al., 2013), with little evidence supporting improved athletic performance or muscle strength (Csapo and Alegre, 2015, Lins et al., 2013). Our results support the hypothesis that applying KTT across the knee stimulates VM activation and increases the VM-to-VL ratio in asymptomatic elite cyclists during submaximal efforts, without inducing significant or clear changes in knee biomechanics.

The VM muscle is the dynamic medial stabilizer of the patella and functionally important in aligning the patella within the patella-femoral joint trochlea, which cannot be readily examined using skin-markers and 3D motion capture. Our KTT application had no mechanical intent, and the altered muscle activation seen here most likely resulted from the enhanced tactile input that altered the excitability of the central nervous system and modulated proprioceptive afferent feedback loops (Simoneau et al., 1997). The enhanced VM activation seen in our cyclists when wearing KTT could be beneficial for preventing patellofemoral pain given that VM is important for the dynamic alignment of the patella. Studies have shown that individuals with PFP exhibit lower activity levels of all vastus muscles during walking (Powers et al., 1996) and VM-to-VL ratios across a range of functional and isometric contraction tasks (Souza and Gross, 1991). Furthermore, delayed onset of EMG activity of the VM in relation to VL (-0.67 ms) has been identified as a contributing factor to the development of PFP in one prospective study (Van Tiggelen et al., 2009). That said, prospective studies on this topic in elite cyclists are needed to confirm the prophylactic effect of patella KTT on knee injury occurrence in this population group.

Although the VM and VL muscles play a critical role in power output during cycling, there is also a high activation of the RF and BF muscles (Akima et al., 2005), with proper co-activation of the hamstrings, which has been suggested to reduce stress at the knee during cycling (So et al., 2005). Hence, reducing the RF-to-BF ratio may have meaningful clinical implications for athletes who exhibit imbalances between knee extensor and flexor strength, poor coordination, and non-optimal activation patterns (i.e., athletes who are quadriceps dominant). With KTT application; there was a clear, likely, and significant decrease in mean BF signals on the dominant side, as well as and peak and mean RF-to-BF ratio values at 100 W on the non-dominant side; with only a small non-significant decrease in RF-to-BF mean observed at 200 W. Despite our results indicating some potential for alterations in RF-to-BF muscle activation patterns, larger sample sizes would be needed to confirm outcomes and implications of these changes.

Most of the neuromuscular effects observed at 100 W became unclear and non-significant at 200 W, pointing to an interaction effect between power output and neuromuscular responses to taping. It is well established that muscle contraction forces increase primarily due to an increase in the number of motor units active and associated firing rates in a non-linear fashion (Merletti and Parker, 2004), with previous cycling studies showing progressive increase in muscle activation with progressive loads from ~150, 220, 290, and 370 W (Carpes et al., 2010a). It is plausible that the effect of KTT on the neuromuscular control diminished with increased overall muscle recruitment, explaining the attenuated effects of KTT at 200 W; however, the underlying mechanisms are unclear given the paucity of literature investigating the effect of KTT at different contraction levels and loads within a given exercise.

The non-dominant and dominant holistically demonstrated comparable responses to KTT, although some clear effects and significant findings were only detected on one side. This discrepancy might be linked to preferred movement patterns of our cyclists, previous injuries with residual neuromuscular inhibition or muscle weakness, or our limited sample size that reduced our statistical power. Most studies suggest that bilateral pedalling asymmetries in terms of power, work, or force increase as the workload decreases (Carpes et al., 2010b), which might explain some of the differential responses between legs that were observed. However, given that work was controlled, and power and force not monitored, the mechanistic reasons behind the between-leg differences remain undetermined.

Perception

Applying RockTape™ to the anterior aspects of the arms and legs and posterior aspects of the neck and back has previously been shown to decrease 'overall' and 'chest' ratings of perceived exertion of trained cyclists, but not alter 'arm' and 'leg' ratings of perceived exertions or gross efficiency (Miller et al., 2015). The physiological findings from this same investigation were unable to support improved athletic performance with RockTape™ use

(Miller et al., 2015). Although most of our cyclists perceived additional knee stability and enhanced performance with KTT; the biomechanical and physiological findings were unable to support that KTT improved knee stability or economy, with KTT application exerting unclear, non-significant, or clearly trivial effects on knee ROM and physiological measures. It is likely that our cyclists' perceptions result from the EMG changes observed or a placebo effect (Mak et al., 2018). Nonetheless, KTT application may still provide some benefits to certain cyclists given the changes observed in the EMG parameters, notably the increased VM activation and alterations in the VM-to-VL and RF-to-BF activation ratios.

Individual responses

One cyclist perceived KTT as uncomfortable and decreasing knee stability. Nonetheless, this particular cyclist felt that KTT improved his performance. This cyclist's data indicated a slight worsening in cycling economy measures at 200 W, with a general increase in knee ROM in all planes of motion with KTT. Simultaneously, EMG signals for VM, VL, and RF, and the VM-to-VL and RF-to-BF ratios increased with KTT, and decreased for BF. In this particular case, perceptions matched well with biomechanical findings, but not necessarily with the physiological ones. In contrast, several cyclists who perceived an increased knee stability, an improved performance, and felt comfortable with KTT application showed 'negative' responses, with their perceptual ratings disagreeing with their objective measures. Hence, although individual data suggest the presences of 'positive responders', 'negative responders', and 'non-responders', we were unable to clearly define subgroups from the subjective data collected.

Limitations

Small sample sizes are an inherent limitation in any high performance sport environment, which reduced our statistical power. All male National Team cyclists available for testing accepted to participate. Our sample size could not be increased further without compromising the external validity of our findings (i.e., testing lower-level cyclists). Future research should examine the repeatability of the effect of KTT application and the potential for any long-term effect or habituation to KTT more thoroughly. We tested only elite male cyclists since the national-level female cyclists were training overseas at the time of data collection and thus the findings may be specific to this population. Female athletes differ physiologically, morphologically, and with respect to injury risk factors compared to male athletes, therefore specific investigations of how female cyclists respond to KTT are warranted. We also acknowledge that the power settings selected were submaximal for elite cyclists and that responses at higher powers might differ. Using lower powers was a necessity to calculate steady state oxygen consumption, economy, and efficiency, and for practical relevance to the National Cycling Team of Malaysia. It should be noted however, that during tour events cyclists often perform for prolonged periods at relatively low levels of power production. For example, Alexander Kristoff's average power output during the first hour of Stage 4 of the 2017 Tour de France was 118 W and his average power output over the entire 4:53:54 of the stage (in which he finished second), was 189 W (www.trainingpeaks.com). Finally, given the minimalist taping technique applied, it was not possible to implement a "placebo" taping method or different taping configurations to confer differences in proprioceptive input.

CONCLUSIONS

Most cyclists perceived increased performance and knee stability with patella KTT, but the intervention had little impact on physiological measures and mostly trivial non-significant effects on knee ROM values. However, patella KTT decreased ROM at the pelvis and trunk at the higher power and appeared to stabilize the segments proximally, which could be a favourable adaptation in cyclists (McDaniel et al., 2005). KTT application did alter EMG responses, notably increasing VM activation and altering the VM-to-VL activation ratio at 100 and 200 W, and changes indicating an increase in BF recruitment in relation to RF at 100 W. Our findings imply that there is a potential for patella KTT to alter neuromuscular recruitment patterns in elite uninjured cyclists, which could have implications for injury prevention and especially the development of PFP by assisting with patella alignment and alleviating knee-joint stress through neuromuscular pathways as opposed to altering knee biomechanics. As such, the neuromuscular changes we observed indicate that cyclists may benefit acutely from patella KTT, although the longitudinal effects of KTT use have not yet been established.

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Table 1. Mean ± SD values for oxygen cost (mL/kg/km), energy cost (kcal/kg/km), cycling economy (W/L/min), heart rate (bpm), and gross efficiency (%) in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 and 200 W cycling efforts. Delta efficiency (%) in NT and KTT conditions is also presented. Differences between conditions are expressed using mean change (Δ_{mean}); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ($P \leq 0.05$) are highlighted in grey.

Parameters	**NT**	**KTT**	$\mathbf{\Delta_{mean}}$	**ES (threshold)**	***P***
			100 W		
Oxygen cost	175.4 ± 30.6	175.2 ± 33.5	-0.2 ± 14.1	-0.01 ± 0.42 (unclear)	0.963
Energy cost	0.86 ± 0.15	0.86 ± 0.16	0.001 ± 0.07	0.001 ± 0.43 (unclear)	0.993
Economy	53.4 ± 5.6	53.6 ± 5.5	0.2 ± 4.5	0.03 ± 0.78 (unclear)	0.885
Heart rate	115.3 ± 9.8	115.6 ± 9.5	0.3 ± 5.8	0.03 ± 0.58 (unclear)	0.845
Gross efficiency	15.5 ± 1.6	15.6 ± 1.6	0.04 ± 1.31	0.02 ± 0.79 (unclear)	0.926
			200 W		
Oxygen cost	277.3 ± 48.0	273.4 ± 46.1	-3.9 ± 12.6	-0.08 ± 0.26 (trivial)[§]	0.311
Energy cost	1.37 ± 0.23	1.35 ± 0.22	-0.02 ± 0.06	-0.09 ± 0.26 (trivial)[§]	0.263
Economy	67.4 ± 5.2	68.4 ± 5.9	1.0 ± 3.1	0.19 ± 0.54 (trivial)	0.303
Heart rate	147.6 ± 9.2	146.8 ± 8.4	-0.8 ± 6.4	-0.08 ± 0.70 (unclear)	0.691
Gross efficiency	19.5 ± 1.5	19.8 ± 1.7	0.3 ± 0.9	0.21 ± 0.54 (small)	0.260
Delta efficiency	26.5 ± 3.1	27.3 ± 2.3	0.8 ± 3.0	0.25 ± 1.04 (unclear)	0.380

Note. An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). [§]Probability of the effect exceeds 75% and is 'likely' to be clinically meaningful.

Table 2. Mean ± SD values for range of motion values (°) in the sagittal (X), coronal (Y), and transverse (Z) planes in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 W cycling efforts for the dominant (D) and non-dominant (ND) sides. Differences between conditions are expressed using mean change (Δ_{mean}); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ($P \leq 0.05$) are highlighted in grey.

Joint	Side	Plane	NT	KTT	Δ_{mean}	ES	*P*
Ankle	ND	X	19.5 ± 8.1	19.9 ± 8.7	0.4 ± 2.1	0.05 (trivial)§	0.517
		Y	5.3 ± 1.7	5.5 ± 1.9	0.2 ± 0.6	0.11 (trivial)§	0.289
		Z	5.7 ± 2.3	5.7 ± 1.9	0.0 ± 1.5	0.02 (unclear)	0.920
	D	X	21.4 ± 4.9	20.3 ± 6.0	-1.1 ± 3.9	-0.22 (small)	0.355
		Y	4.3 ± 1.8	5.0 ± 1.7	0.6 ± 1.2	0.35 (small)§	0.097
		Z	5.5 ± 0.7	5.2 ± 1.0	-0.3 ± 1.1	-0.44 (unclear)	0.350
Knee	ND	X	76.7 ± 3.1	76.2 ± 3.6	-0.5 ± 1.5	-0.16 (trivial)	0.270
		Y	9.2 ± 3.6	9.0 ± 3.3	-0.2 ± 1.5	-0.04 (trivial)§	0.727
		Z	9.2 ± 4.9	9.3 ± 3.9	0.1 ± 2.6	0.03 (unclear)	0.867
	D	X	78.8 ± 2.3	78.2 ± 2.2	-0.5 ± 1.7	-0.23 (small)	0.304
		Y	8.3 ± 2.6	8.1 ± 2.3	-0.2 ± 1.1	-0.08 (trivial)§	0.526
		Z	12.3 ± 5.3	12.4 ± 4.7	0.0 ± 1.8	0.003 (trivial)§	0.976
Hip	ND	X	48.7 ± 3.5	48.8 ± 3.8	0.1 ± 1.5	0.02 (unclear)	0.901
		Y	6.3 ± 3.4	6.2 ± 2.8	0.0 ± 1.3	-0.01 (trivial)§	0.915
		Z	11.5 ± 3.8	11.4 ± 4.3	0.0 ± 1.8	-0.01 (unclear)	0.937
	D	X	47.5 ± 2.9	47.4 ± 2.8	- 0.1 ± 1.1	-0.04 (trivial)§	0.694
		Y	6.6 ± 1.8	6.6 ± 1.9	0.0 ± 1.4	-0.005 (unclear)	0.983
		Z	10.0 ± 3.7	9.5 ± 3.2	- 0.5 ± 1.4	-0.12 (trivial)	0.283
Pelvis		X	8.1 ± 1.8	8.3 ± 2.2	0.2 ± 1.4	0.10 (unclear)	0.647
		Y	3.5 ± 0.9	3.6 ± 1.1	0.1 ± 0.5	0.09 (trivial)	0.561
		Z	3.7 ± 1.9	3.6 ± 1.3	- 0.1 ± 2.2	-0.05 (unclear)	0.881
Trunk		X	8.8 ± 3.9	10.1 ± 8.2	1.3 ± 8.9	0.34 (unclear)	0.620
		Y	0.8 ± 0.2	0.7 ± 0.2	0.0 ± 0.1	-0.07 (trivial)§	0.643
		Z	8.4 ± 4.1	9.6 ± 8.5	1.2 ± 9.4	0.30 (unclear)	0.663

Notes. Sagittal (X): ankle dorsiflexion and plantar flexion, knee and hip flexion and extension, pelvis and trunk anterior and posterior tilt; Coronal (Y): ankle inversion and eversion, knee valgus and varus, hip abduction and adduction, pelvis and trunk non-dominant side and dominant side tilt; Transverse (Z) ankle, knee, and hip internal and external rotation, pelvis and trunk non-dominant side and dominant side rotation. An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). §Probability of the effect exceeds 75% and is 'likely' to be clinically meaningful.

Table 3. Mean ± SD values for range of motion values (°) in the sagittal (X), coronal (Y), and transverse (Z) planes in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 200 W cycling efforts for the dominant (D) and non-dominant (ND) sides. Differences between conditions are expressed using mean change (Δ_{mean}); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ($P \leq 0.05$) are highlighted in grey.

Joint	Side	Plane	NT	KTT	Δ_{mean}	ES	*P*
Ankle	ND	X	21.7 ± 7.8	22.7 ± 8.3	1.0 ± 2.6	0.12 (trivial)[§]	0.235
		Y	5.9 ± 2.0	6.2 ± 2.6	0.2 ± 1.0	0.11 (trivial)	0.450
		Z	5.9 ± 1.8	5.7 ± 1.9	-0.2 ± 1.0	-0.11 (trivial)	0.529
	D	X	24.0 ± 6.9	24.7 ± 5.7	0.7 ± 3.0	0.10 (trivial)[§]	0.435
		Y	4.7 ± 1.3	4.9 ± 1.5	0.2 ± 0.6	0.14 (trivial)	0.342
		Z	6.0 ± 1.6	5.8 ± 1.7	-0.2 ± 0.4	-0.14 (trivial)[§]	0.123
Knee	ND	X	78.4 ± 3.7	78.9 ± 3.1	0.5 ± 1.7	0.14 (trivial)	0.302
		Y	8.3 ± 2.6	8.2 ± 2.6	-0.7 ± 1.4	-0.03 (unclear)	0.849
		Z	9.4 ± 4.1	8.8 ± 3.1	-0.6 ± 1.8	-0.14 (trivial)	0.277
	D	X	80.1 ± 2.3	80.9 ± 2.5	0.8 ± 2.1	0.34 (small)	0.224
		Y	7.7 ± 2.1	8.1 ± 2.1	0.4 ± 0.9	0.19 (trivial)	0.146
		Z	11.5 ± 4.5	11.2 ± 4.5	-0.3 ± 1.6	-0.07 (trivial)[§]	0.496
Hip	ND	X	49.6 ± 3.9	49.3 ± 4.5	-0.9 ± 2.1	-0.07 (unclear)	0.661
		Y	7.4 ± 3.7	7.4 ± 3.4	0.0 ± 1.0	0.001 (trivial)[§]	0.988
		Z	11.5 ± 3.4	12.1 ± 3.4	0.6 ± 1.7	0.18 (trivial)	0.245
	D	X	47.4 ± 2.8	47.5 ± 2.4	0.1 ± 1.4	0.02 (unclear)	0.874
		Y	7.1 ± 2.5	6.9 ± 2.2	-0.3 ± 1.2	-0.10 (trivial)	0.490
		Z	10.3 ± 3.1	10.4 ± 3.2	0.1 ± 1.5	0.03 (unclear)	0.812
Pelvis		X	8.4 ± 2.4	7.9 ± 2.2	-0.5 ± 1.1	-0.19 (trivial)	0.178
		Y	3.5 ± 1.3	3.7 ± 1.5	0.2 ± 0.5	0.14 (trivial)	0.269
		Z	4.0 ± 1.8	3.6 ± 1.1	-0.4 ± 1.8	-0.22 (unclear)	0.447
Trunk		X	9.5 ± 4.2	8.6 ± 2.7	-0.9 ± 3.4	-0.21 (unclear)	0.391
		Y	0.9 ± 0.5	0.9 ± 0.3	0.0 ± 0.3	-0.04 (unclear)	0.834
		Z	8.6 ± 3.8	7.8 ± 2.6	-0.9 ± 3.6	-0.22 (unclear)	0.430

Notes. Sagittal (X): ankle dorsiflexion and plantar flexion, knee and hip flexion and extension, pelvis and trunk anterior and posterior tilt; Coronal (Y): ankle inversion and eversion, knee valgus and varus, hip abduction and adduction, pelvis and trunk non-dominant side and dominant side tilt; Transverse (Z) ankle, knee, and hip internal and external rotation, pelvis and trunk non-dominant side and dominant side rotation. An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). [§]Probability of the effect exceeds 75% and is 'likely' to be clinically meaningful.

Table 4. Mean ($\%_{max}$), peak ($\%_{max}$), and integrated EMG (iEMG, $\%_{max}$) signal values (mean ± SD) for the *vastus medialis* (VM), *vastus lateralis* (VL), *rectus femoris* (RF), and *biceps femoris* (BF) muscles in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 100 W cycling efforts for the dominant (D) and non-dominant (ND) sides. The VM-to-VL and RF-to-BF activation ratios are also presented. Differences between conditions are expressed using mean change (Δ_{mean}); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ($P \leq 0.05$) are highlighted in grey.

Muscle	Side	EMG	NT	KTT	Δ_{mean}	ES (threshold)	*P*
VM	ND	Peak	**29.5 ± 5.9**	**37.4 ± 5.1**	**8.0 ± 7.4**	1.35 (large)[§]	0.047
		iEMG	39.9 ± 10.1	47.3 ± 7.9	7.3 ± 9.9	0.72 (moderate)[§]	0.128
		Mean	9.4 ± 1.7	9.2 ± 2.6	-0.2 ± 2.6	-0.13 (unclear)	0.840
	D	Peak	31.4 ± 9.3	39.5 ± 8.0	8.1 ± 10.1	0.87 (moderate)[§]	0.056
		iEMG	38.1 ± 11.9	49.7 ± 16.0	11.7 ± 8.9	0.98 (moderate)[§]	0.024
		Mean	**7.9 ± 2.1**	**9.9 ± 2.2**	**2.0 ± 2.1**	0.95 (moderate)[§]	0.030
VL	ND	Peak	39.3 ± 11.0	36.8 ± 8.0	-2.5 ± 15.8	-0.23 (unclear)	0.717
		iEMG	47.3 ± 11.0	36.8 ± 8.0	-0.5 ± 18.0	-0.05 (unclear)	0.950
		Mean	9.4 ± 1.7	9.2 ± 2.6	-0.2 ± 2.6	-0.13 (unclear)	0.840
	D	Peak	37.0 ± 5.4	36.9 ± 8.2	-0.2 ± 10.0	-0.03 (unclear)	0.965
		iEMG	44.7 ± 10.1	47.2 ± 12.4	2.5 ± 10.2	0.25 (unclear)	0.545
		Mean	8.7 ± 1.8	9.0 ± 2.4	0.2 ± 1.8	0.13 (unclear)	0.725
RF	ND	Peak	24.7 ± 4.5	22.7 ± 2.5	-2.0 ± 5.7	-0.44 (unclear)	0.482
		iEMG	35.1 ± 6.8	33.0 ± 4.4	-2.1 ± 4.8	-0.30 (unclear)	0.391
		Mean	7.5 ± 1.0	7.0 ± 0.6	-0.6 ± 1.0	-0.54 (unclear)	0.279
	D	Peak	29.6 ± 11.0	25.2 ± 8.7	-4.3 ± 4.3	-0.39 (small)[§]	0.135
		iEMG	39.0 ± 10.0	36.1 ± 5.8	-3.0 ± 4.6	-0.30 (unclear)	0.287
		Mean	7.3 ± 1.3	6.7 ± 0.7	-0.7 ± 0.6	-0.51 (small)[§]	0.137
BF	ND	Peak	37.2 ± 11.9	39.2 ± 8.6	1.9 ± 6.0	0.16 (unclear)	0.514
		iEMG	42.8 ± 11.7	42.8 ± 6.7	-0.9 ± 9.3	-0.08 (unclear)	0.830
		Mean	7.9 ± 2.0	8.4 ± 1.5	0.5 ± 1.1	0.25 (unclear)	0.351
	D	Peak	42.0 ± 5.2	38.5 ± 3.3	-3.5 ± 3.2	-0.67 (moderate)[§]	0.120
		iEMG	42.7 ± 5.1	40.7 ± 4.7	-2.1 ± 3.3	-0.41 (unclear)	0.303
		Mean	7.6 ± 1.3	7.4 ± 1.4	-0.6 ± 0.3	-0.36 (small)[§]	0.044
VM:VL	ND	Peak	81.6 ± 8.0	99.2 ± 12.2	17.6 ± 19.8	2.20 (very large)[§]	0.118
		iEMG	82.2 ± 16.0	102.4 ± 18.3	20.1 ± 24.2	1.26 (large)[§]	0.097
		Mean	76.8 ± 11.0	95.4 ± 14.2	18.6 ± 22.8	0.95 (moderate)[§]	0.088
	D	Peak	75.1 ± 14.7	107.2 ± 29.2	32.1 ± 18.8	2.19 (large)[§]	0.009
		iEMG	84.9 ± 14.0	107.7 ± 26.0	22.8 ± 16.6	1.63 (large)[§]	0.020
		Mean	91.9 ± 19.6	115.6 ± 27.7	23.7 ± 23.4	1.21 (large)[§]	0.029
RF:BF	ND	Peak	68.0 ± 21.8	58.8 ± 18.7	-9.1 ± 6.5	-0.42 (small)[§]	0.021
		iEMG	85.6 ± 19.8	80.7 ± 16.0	-5.0 ± 13.1	-0.25 (unclear)	0.445
		Mean	99.5 ± 22.8	85.5 ± 17.2	-14.0 ± 7.8	-0.62 (moderate)[§]	0.016
	D	Peak	69.5 ± 18.8	65.4 ± 20.2	-4.1 ± 8.1	-0.22 (unclear)	0.388
		iEMG	91.6 ± 23.6	89.5 ± 18.2	-2.1 ± 5.7	-0.09 (trivial)	0.514
		Mean	93.9 ± 23.6	91.6 ± 18.2	-2.3 ± 5.5	-0.10 (trivial)	0.456

Note. An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). [§]Probability of the effect exceeds 75% and is ‘likely’ to be clinically meaningful.

Table 5. Mean (%$_{max}$), peak (%$_{max}$), and integrated EMG (iEMG, %$_{max}$) signal values (mean ± SD) for the *vastus medialis* (VM), *vastus lateralis* (VL), *rectus femoris* (RF), and *biceps femoris* (BF) muscles in the No Tape (NT) and Kinesiology-Type Tape (KTT) conditions during the 200 W cycling efforts for the dominant (D) and non-dominant (ND) sides. The VM-to-VL and RF-to-BF activation ratios are also presented. Differences between conditions are expressed using mean change (Δ_{mean}); standardized effect size (ES); and paired *t*-test statistical significance values (*P*). Thresholds for clear ES are provided (trivial, small, large, and very large) and significant changes ($P \leq 0.05$) are highlighted in grey.

Muscle	Side	EMG	NT	KTT	Δ_{mean}	ES (threshold)	*P*
VM	ND	Peak	39.4 ± 9.4	48.0 ± 4.4	8.6 ± 12.7	0.92 (moderate)§	0.122
		iEMG	**58.2 ± 9.6**	**68.1 ± 5.7**	**9.9 ± 7.7**	1.04 (moderate)§	0.014
		Mean	10.7 ± 1.5	12.1 ± 1.8	1.4 ± 1.8	0.92 (moderate)§	0.088
	D	Peak	47.0 ± 9.4	48.2 ± 5.3	1.2 ± 10.9	0.13 (unclear)	0.741
		iEMG	69.1 ± 10.7	70.1 ± 6.2	1.0 ± 11.4	0.09 (unclear)	0.830
		Mean	13.0 ± 2.4	14.1 ± 1.7	1.1 ± 3.0	0.46 (unclear)	0.380
VL	ND	Peak	46.4 ± 9.5	47.7 ± 6.2	1.3 ± 12.4	0.13 (unclear)	0.797
		iEMG	66.4 ± 6.9	68.9 ± 11.5	2.5 ± 13.7	0.37 (unclear)	0.643
		Mean	12.8 ± 1.8	12.8 ± 3.2	0.1 ± 2.2	0.05 (unclear)	0.924
	D	Peak	50.2 ± 7.0	47.7 ± 9.0	-2.6 ± 9.3	-0.37 (unclear)	0.433
		iEMG	65.8 ± 8.1	69.4 ± 9.0	3.6 ± 9.4	0.45 (unclear)	0.284
		Mean	13.0 ± 1.6	13.1 ± 2.1	0.1 ± 1.7	0.09 (unclear)	0.831
RF	ND	Peak	34.4 ± 12.6	37.1 ± 2.5	2.8 ± 14.5	0.22 (unclear)	0.657
		iEMG	54.4 ± 15.9	53.7 ± 6.7	-0.7 ± 15.1	-0.04 (unclear)	0.906
		Mean	11.9 ± 3.0	11.9 ± 1.7	-0.1 ± 3.4	-0.02 (unclear)	0.971
	D	Peak	39.5 ± 10.1	40.8 ± 6.6	1.3 ± 7.2	0.13 (unclear)	0.672
		iEMG	62.1 ± 11.9	63.7 ± 7.8	1.6 ± 13.6	0.14 (unclear)	0.761
		Mean	11.6 ± 1.7	11.4 ± 1.8	-0.2 ± 2.2	-0.11 (unclear)	0.844
BF	ND	Peak	42.6 ± 11.6	45.1 ± 6.4	2.6 ± 16.0	0.22 (unclear)	0.711
		iEMG	57.8 ± 12.9	58.8 ± 8.7	1.0 ± 12.9	0.08 (unclear)	0.846
		Mean	12.7 ± 4.8	12.2 ± 3.0	-0.5 ± 3.7	-0.11 (unclear)	0.735
	D	Peak	44.1 ± 8.1	38.5 ± 5.9	-5.6 ± 6.2	-0.69 (moderate)§	0.077
		iEMG	52.8 ± 13.1	52.8 ± 6.8	0.0 ± 13.4	-0.01 (unclear)	0.999
		Mean	10.7 ± 3.1	9.6 ± 2.1	-1.0 ± 2.4	-0.34 (unclear)	0.338
VM:VL	ND	Peak	85.6 ± 8.5	97.6 ± 15.5	11.9 ± 17.6	1.41 (large)§	0.157
		iEMG	87.8 ± 12.8	101.5 ± 20.9	13.7 ± 20.3	0.88 (moderate)§	0.124
		Mean	84.6 ± 6.8	98.7 ± 21.5	14.2 ± 19.2	2.07 (very large)§	0.098
	D	Peak	94.8 ± 19.3	98.5 ± 19.8	3.8 ± 27.2	0.20 (unclear)	0.707
		iEMG	96.6 ± 20.9	104.4 ± 18.3	7.8 ± 23.1	0.37 (unclear)	0.340
		Mean	100.2 ± 13.1	110.8 ± 27.9	10.6 ± 25.2	0.80 (unclear)	0.311
RF:BF	ND	Peak	82.6 ± 24.3	83.3 ± 9.7	0.7 ± 30.6	0.03 (unclear)	0.955
		iEMG	98.3 ± 34.4	92.9 ± 18.2	-5.3 ± 27.1	-0.16 (unclear)	0.620
		Mean	120.1 ± 34.2	106.7 ± 16.2	-13.4 ± 19.2	-0.39 (small)§	0.194
	D	Peak	92.5 ± 27.2	106.8 ± 17.0	14.3 ± 24.7	0.53 (unclear)	0.214
		iEMG	124.1 ± 36.9	121.5 ± 15.1	-2.7 ± 40.3	-0.07 (unclear)	0.867
		Mean	118.3 ± 43.9	121.8 ± 27.7	3.6 ± 37.6	0.09 (unclear)	0.825

Note. An effect was deemed 'unclear' when its 90% confidence limit overlapped the thresholds for small positive and small negative effects (i.e., 5%). §Probability of the effect exceeds 75% and is 'likely' to be clinically meaningful.

Figure captions

Figure 1. Cyclist set-up for data collection with the patella kinesiology-type tape (KTT) applied.

Figure 2. Marker placement for 3D motion capture from anterior (left), posterior (middle), and lateral (right) views. Anatomical reference markers were placed bilaterally on the acromial processes, anterior superior iliac spines, posterior superior iliac spines, greater trochanters, medial and lateral femoral epicondyles, medial and lateral malleoli, and 1^{st} and 5^{th} metatarsal heads. Tracking markers were placed bilaterally on the heel, mid-foot, and forefoot, and 4-marker rigid clusters were placed on the lateral aspect of the pelvis and bilaterally on the lateral aspects of the thighs and shanks. Anterior superior iliac spine, greater trochanter, femoral epicondyle, malleolus, and 1^{st} metatarsal head markers were removed before the dynamic cycling efforts (red circles).

Figure 3. Ratings of comfort levels and perceived change in knee stability and cycling performance with the application of kinesiology-type tape (KTT) compared to no tape (NT) on a 5-point Likert scale. Data presented are the number of cyclists (*n*) that provided a given rating. Comfort level: 1, very uncomfortable; 2, uncomfortable; 3, no change; 4, comfortable; 5, very comfortable. Knee stability: 1, much less stable; 2, less stable; 3, no change; 4, more stable; 5, much more stable. Performance: 1, much worse; 2, worse; 3, no change; 4, better; 5, much better.