Kinesio Taping does not Enhance Jump Performance and Muscle Activity in Female Athletes

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ABSTRACT

This study aimed to investigate the effect of Kinesio Taping (KT) application on the single-leg counter-movement jump (CMJ) and surface electromyographic (sEMG) activity in trained female athletes, in both resting and fatigued states. In this single-blind, randomized, sham-controlled trial, twenty-four healthy trained female athletes were randomly assigned to either the KT (n = 12) or the sham tape group (n = 12). KT was applied using an inhibition technique on rectus femoris, vastus medialis, biceps femoris, and lateral gastrocnemius muscles of the dominant leg. A single-leg CMJ test and sEMG activity were recorded at baseline (no tape), as well as at 1 hour, 24 hours, and 48 hours after taping. To induce acute neuromuscular fatigue, a 30-second repetitive CMJ test was used to evaluate KT in fatigued states. In the resting states, both groups exhibited improvements in jump height, power, mean velocity, and sEMG activity (%EMGmax) over time, with no significant between-group differences. The single-leg CMJ performance was similarly decreased after the muscle fatigue protocol in both groups, showing no between-group differences. Our findings suggest that KT treatment does not appear to influence jumping performance, sEMG activity, or muscle fatigue in female athletes.

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Introduction

Lower limb power holds significant importance for decision-making moments in competitive scenarios (i.e., team sports) and transitions between defensive and offensive actions (i.e., combat sports) and for sprint performance [1]. A vertical jump, considered an expression of lower limb power, is a commonly utilized assessment tool within sports and exercise tests [2]. A single-leg counter-movement jump (CMJ) is frequently used as a measure of leg power and surrogate of knee extension strength, thereby indicating athletic prowess [3]. Its effectiveness also extends to assessing an athlete's readiness to return to sports post-injury [4]. While the impact of dominant leg utilization on sport-specific performances may vary, it is

notable that numerous functional movements and body weight transfer tasks are predominantly executed with the dominant leg [5]. For athletic performance assessments, the discernment of neuromuscular behavior, as indicated by surface electromyography (sEMG), is paramount, in addition to factors such as muscle power and ground reaction force during jumping [6].

The pursuit of maintaining peak performance in competitive sports hinges directly on the body's ability to respond to sport-specific and intense exercises. In the current landscape, competitive athletes are increasingly seeking supportive methods to optimize performance, reduce the risk of injury, and expedite recovery. Alongside popular ergogenic modalities such as dietary supplements and mental interventions, Kinesio taping (KT) has emerged as a widely adopted tool by athletes and clinicians, primarily for enhancing the performance and treating musculoskeletal injuries [7]. In contrast to traditional taping methods used in athletic performance, KT is characterized by its elastic adhesive nature, capable of stretching close to the stretching capacity of the human skin, up to 140 % of its normal state [8]. Upon initial application, KT generates a recoil effect, adhering to the skin and lifting the epidermis layer, thereby allowing the dermis layer to spread across a greater area. Moreover, its facilitation of lymphatic drainage may serve to reduce inflammation by enhancing blood flow in the application area. This may have significant implications for muscle performance and recovery [9]. The direction of KT application from the muscle origin to its insertion or vice versa indicates whether a facilitatory or inhibitory taping technique is used. However, in practical settings, there remains some disagreement about which technique is more effective for enhancing the muscle performance [10]. Generally, facilitatory techniques are applied in cases of injury where increased muscle activation is necessary, such as with sprains or strains. In contrast, the inhibitory technique of KT is designed to promote muscle relaxation, which can lead to improved muscle performance and total work output following exercise-induced fatigue [11]. Additionally, research has demonstrated that KT can effectively manage pain by inhibiting muscle activity [12].

Despite the widespread use of KT among competitive athletes across various sports disciplines, several systematic reviews and meta-analyses analyzing the effect of KT on athletic performance have shown incongruent findings [8, 13–15]. A recent scoping review, encompassing 50 studies, indicated that 46 % of the included research supported the efficacy of KT while the remaining studies suggested its inefficacy [7]. These conflicting outcomes could stem from various methodological constraints, such as the absence of participants and assessor blinding, inadequate acknowledgment of KT's potential placebo effects, and studies conducting multiple analyses without sufficient adjustment for type I error, potentially resulting in chance significant findings. Conflicting results are also found regarding the impact of KT on muscle fatigue. While some investigations have reported a positive effect of KT in reducing muscle fatigue following physical exertion in both upper and lower limb muscles [11, 16], others have found no influence of KT under fatigued conditions [17, 18]. Recently Ataabadi et al. [19] found no significant differences in the fatigue rate and knee extensor sEMG activity during 100 dynamic repeated contractions when comparing KT inhibitory, facilitatory, sham tape, and no tape conditions. Notably, none of these studies blinded the outcome assessor to the treatment allocation and some of them did not include a control group which may lead to biased treatment effect estimates due to participants or assessor expectations. It is evident that study design is a crucial factor in determining the potential influence of KT on athletic performance and fatigue. Overall, the inconsistency in findings regarding KT highlights the need for more rigorously designed studies to better ascertain its true impact on athletic setting. The effect of KT on athletic performance was also investigated across various time intervals, considering a potential adaptation period for its effects to manifest. Accordingly, some studies reported significant enhancements in performance metrics like the vertical jump, balance, and agility over time (i.e., 24, 48, and 72 h) after KT application [20–22]. However, despite these promising findings, further research is essential to validate and generalize these results over time and to advocate for the broader integration of KT into sports sciences. Therefore, the purpose of this study was to ascertain the efficacy of KT application on single-leg CMJ performance and sEMG activity in both resting and fatigued states in trained female athletes. This will contribute to the broader understanding of the effects of KT, particularly concerning muscle performance and fatigue, aiding in formulating more informed practices and recommendations within the field. We hypothesized that the KT application would enhance muscle performance (i.e., single-leg CMJ performance and sEMG activity) in both resting and fatigued states in competitive female athletes. To test this hypothesis, the present study implemented a single-blind and sham-controlled design to investigate the potential effects of KT on athletic performance parameters in trained female athletes across different metabolic conditions.

Materials and methods

Participants

Thirty trained female athletes were initially enrolled. After three participants declined to participate and three were excluded due to prior lower extremity surgeries, a total of 24 healthy trained female athletes (aged 19–24 years) were randomly assigned to either the KT group ($n = 12$) or the sham tape group ($n = 12$) using a computer-generated randomization table in Microsoft Excel by a statistician not involved in the study. The participants were students in the sports department of a state university, following a curriculum that included strength and conditioning-related courses. They were engaged in training sessions related to specific sports (e.g., soccer, volleyball, track and field) at least three times per week (i.e., trained athletes) [23]. Leg dominance was determined using the procedure outlined by Muehlbauer et al. [24]. The baseline characteristics of the participants are detailed in ▶ **Table 1**.

The inclusion criteria were specified as follows: (1) aged between 18 and 25 years, (2) participating in individual or team training sessions at least three times per week, (3) the absence of musculoskeletal pain or injury during the study, and (4) regularly attending to lower extremity strengthening exercises. The exclusion criteria included: (1) having undergone lower limb surgery within the last 6 months, (2) the presence of skin issues or contraindications for tape application, (3) prior experience of KT treatment, and (4) being in the premenstrual or menstrual phases. Additionally, par-

▶ **Table 1** Baseline characteristics of the participants ($n = 24$).

Variables	Kinesio tape ($n = 12$)	Sham ($n = 12$)	*p*-value
Age (years)	21.3 (1.4)	21.2 (1.5)	0.786
Height (m)	1.6 (0.1)	1.6 (0.1)	0.566
Weight (kg)	55.9 (6.1)	53.4 (6.4)	0.331
Body mass index (kg/m^2)	20.8 (1.9)	20.2 (2.0)	0.461
Sport experience (years)	7.1 (2.4)	6.4 (1.7)	0.438
Data are reported as mean (standard deviation).			

ticipants were instructed to abstain from alcohol consumption, using any ergogenic aids, and engaging in heavy physical activities that might impact study outcomes throughout the investigation (i.e., 48 h).

All participants were fully informed about the experimental procedures including the study duration, daily activities with the KT, and potential risks and provided both verbal and written informed consent before any intervention. This research was approved by the Clinical Research Ethics Board at Karamanoğlu Mehmetbey University (Approval no: 9–2022/10; date: 5/10/2022) and was conducted in accordance with the Declaration of Helsinki.

Study design and procedures

This study was a single-blind, sham-controlled trial to investigate the effects of KT on single-leg CMJ performance and sEMG activity in both resting and fatigued states, in trained female athletes. The dependent variables included a single-leg (dominant leg) CMJ and sEMG activation of the rectus femoris (RF), vastus medialis (VM), biceps femoris (BF), and lateral gastrocnemius (LG) muscles of the dominant leg. Prior to taping and main testing, enrolled participants underwent baseline (no tape) assessments at least of 48 h in advance. These assessments covered demographic and anthropometric measurements as well as a randomization process. The randomization process was completed in a closed and isolated room. Only the certified KT practitioner (ZD, the fifth author of the study) responsible for applying the KT had knowledge of the treatment allocation and was independent of the data collection process and its further analysis. Additionally, a familiarization session was conducted to minimize potential learning effects.

During the first intervention visit (Day 1), KT was applied to both the KT and sham tape groups by ZD in a single-blinded manner, remaining on the skin for 48 h. Day 1 also involved the baseline (no tape) and the first postapplication measurements (1 h after KT application) of the single-leg CMJ and sEMG activation in a resting state. These same assessments were repeated 24 h (Day 2) and 48 h (Day 3) after KT application, while the participants were in a resting state. Furthermore, Days 1, 2, and 3 were used to evaluate the effects of KT on single-leg CMJ performance in a fatigued state (▶ **Fig. 1**).

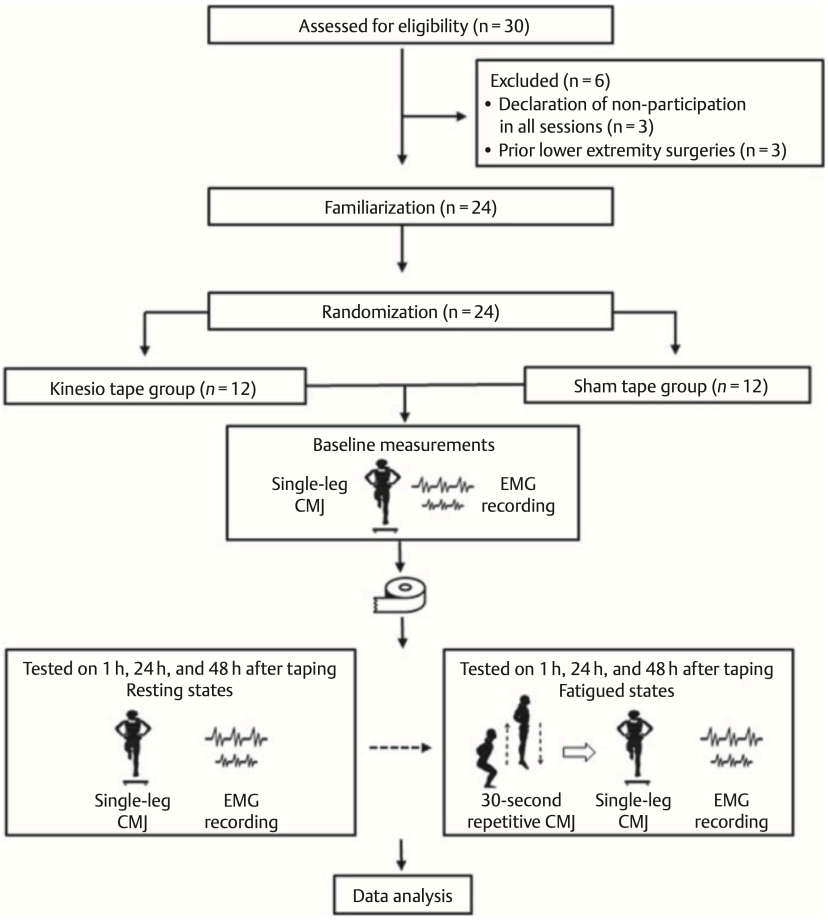
To induce acute neuromuscular fatigue, a single bout of the 30-s repetitive CMJ ($RCMJ_{30}$) test, an indicator of anaerobic power [25], was conducted immediately following the resting single-leg CMJ and electromyographic sEMG measurements on each individual's test day. During the $RCMJ_{30}$, participants were instructed to flex their knees to approximately 90 ° during the transition between the eccentric and concentric phases, a position considered optimal for maximizing the vertical jump performance. Pre–post differences on jump performance variables (i.e., jump height, jump power, and jump mean velocity) after the $RCMJ_{30}$ test were used as muscle fatigue indicators. To mitigate potential variations in physiological responses due to circadian rhythm, all measurements were taken at the same time of day (1:00 PM). These measurements were consistently carried out by the same researcher in the sports physiology laboratory of a local state university, ensuring uniform environmental conditions (e.g., temperature at 25 °C, the absence of noise and external interference) [26]. The blinded nature of the study was maintained by performing raw data filtering, entry, and statistical analysis without knowledge of the KT interventions.

KT application

The skin was prepared for the taping application by shaving and cleaning it with rubbing alcohol. Kinesio tape (Kinesio Tex Gold, Albuquerque, New Mexico (NM)) with a width of 5 cm and a thickness of 0.5 mm was employed for taping. This specific tape, capable of stretching to 140 % of its original length, is designed for comfortable wear for 3–5 days due to its latex-free, cotton, and water-resistant fabric. Following the guidelines developed by Kase et al. [27], the KT was applied from the muscle insertion to its origin (distal to proximal). In the KT group, an inhibition technique was used during taping to the RF, VM, BF, and LG of the dominant leg, with 15–20 % tension [21]. For the RF, VM, and BF muscles, the KT was applied in an I-shape while the LG muscle was taped in a Y-shape [27]. During taping, the participants were instructed to maintain a sitting position for RF and VM muscles and a standing position for BF and LG muscles. Furthermore, the electrodes were positioned on the belly of each muscle, providing a suitable surface for them, by making slight cuts in the tape (▶ **Fig. 2**). The sham tape group underwent a similar application of KT using I and Y-strips, replicating the actual application, but without any tension or specific taping techniques. The tape remained on the skin for 48 h in both groups. To guard against the placebo effect, both the participants and the study team (except for the KT practitioner) were blinded to the group assignment.

Single-leg CMJ test

Before starting the single-leg CMJ test, athletes performed a 10-min warm-up, consisting of medium-intensity aerobic, stretching, mobility, and coordination exercises. The data for the single-leg CMJ test were collected using a portable force plate (Kistler, Winterthur, Switzerland; type 9260AA6; 600 × 500 × 50 mm; natural frequency ≈ 400 Hz) recognized as a gold standard for evaluating vertical jumping performance. Participants began the test by assuming a unilateral stance with the dominant leg fully extended and positioned at the center of the force plate, while the alternate leg at hip level with the knee joint at 90 ° flexion [28]. They were then instructed to jump as high as possible and to land on the same tested leg after performing a counter-movement to a self-selected depth. Throughout the entire movement, participants were required to keep their hands on their hips, and the tested leg had to remain fully extended during the flight phase, with the swing of the opposite leg restricted [3]. Any repetition that did not adhere to these instructions was regarded as invalid and was repeated. The best perfor-



▶ **Fig 1** A flow diagram of the participants and data collection process CMJ, counter-movement jump; EMG, Electromyography.

mance out of a total of three successful repetitions was used for the analysis. A 30-s recovery period was provided between repetitions to prevent fatigue. The global parameters of the single-leg CMJ test, including the jump height calculated from flight time (m), jump power (W/kg), and jump mean velocity (m/s), were obtained using Kistler's Measurement, Analysis & Reporting Software (MARS) for subsequent analyses. These outcomes have shown acceptable relative reliability (intraclass correlation coefficient >0.8) in trained athletes [3].

Electromyography and data processing

The sEMG activities of the RF, VL, BF, and LG muscles on the dominant leg were recorded during the single-leg CMJ test using a 16-channel wireless EMG system (Ultium EMG, Noraxon USA Inc., Scottsdale, AZ, USA). After skin shaving and cleaning with isopropyl alcohol to reduce electrical impedance, signals were recorded using disposable unipolar Ag/AgCl self-adhesive gel electrodes (25.4 mm × 25.4 mm) with a 20 mm interelectrode distance. These electrodes were placed on the skin over the most suitable location on the belly of each muscle, parallel to the muscle fiber direction, in accordance with SENIAM guidelines [29]. Wireless EMG sensors (Noraxon USA, Inc.) were then attached to the electrodes following precise placement (▶ **Fig. 1**). Following the positioning of the sensors and electrodes, reference marks were drawn on each participant's skin to ensure accurate repositioning for subsequent assessments. The real-time sEMG signals were sampled at a frequency of 4,000 Hz and were transmitted via the wireless sensors to a receiver (Desktop DTS Receiver, Noraxon USA. Inc.) connected to a personal laptop running myoMUSCLE software.

The raw sEMG signals were exported as an Excel file and further analyzed using MATLAB 2019b (MathWorks, USA) by an EMG data analyst (HD, sixth author of the study) who was blinded to the treatment allocation. The sEMG data band-pass filtered within the range of 20–500 Hz using a fourth-order low-pass Butterworth filter. After verifying the absence of noise or motion artifacts, the sEMG signals were rectified and subsequently low-pass filtered at 50 Hz. The signals were further processed to generate linear envelopes through data smoothing. These linear envelopes, corresponding to each muscle, were then normalized to the highest observed signal (% max) during the single-leg CMJ at four different time points (i.e., baseline, 1, 24, and 48 h following taping) [30]. Additionally, an integrated EMG (iEMG) signal was computed by integrating the linear envelope from the start to the end

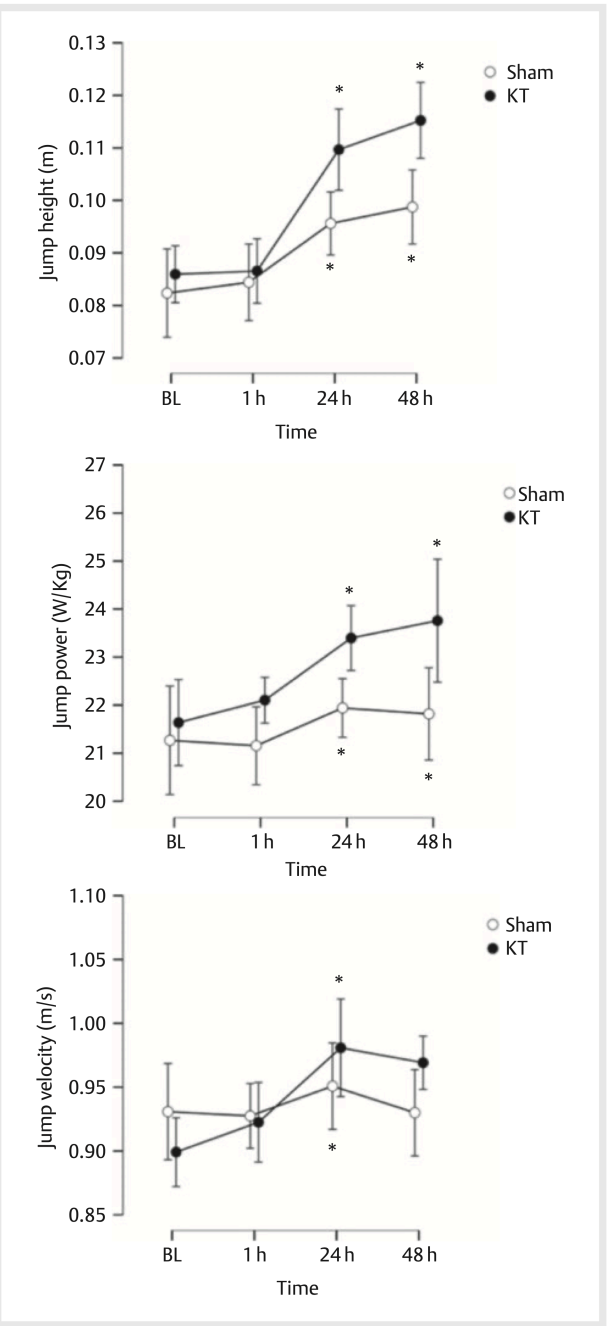


▶ **Fig. 2** Application of Kinesio Taping to the rectus femoris, vastus medialis, biceps femoris, and lateral gastrocnemius muscles and electrode placements.

of the jumping task, which was then normalized to the maximal observed iEMG across all four efforts as a percentage of the peak sEMG activity. Finally, mean %EMG$_{max}$ and iEMG values were used for further analyses.

Statistical analysis

Statistical analyses were performed using JASP software (version 0.17.1, JASP Team). The normal distribution was confirmed using the Shapiro–Wilk test. Continuous variables were presented as means and standard deviations. The independent sample *t*-test was used to compare baseline characteristics (i.e., age, height, weight, body mass index, and sport experience) between the KT and sham tape groups. To evaluate whether KT influenced single-leg CMJ performance parameters and muscle fatigue, a two-way repeated measures ANOVA was used. Greenhouse-Geisser correction was applied when Mauchly's assumption of sphericity was violated. If significant effects were observed, these were followed up by post hoc Bonferroni-corrected pairwise comparisons. Partial eta square (η_p^2) was reported as an estimate of effect size, with $\eta_p^2 \geq 0.07$ and $\eta_p^2 \geq 0.14$ interpreted as moderate and large effects, respectively. The level of statistical significance was set at $p<0.05$.



▶ **Fig. 3** Time effect and time-by-group comparisons for jump performance variables. KT group and BL. Error bars represent the 95% confidence interval. Post hoc Bonferroni comparisons revealed differences statistically significant compared to BL (*). BL, baseline; KT, Kinesio taping.

Results

Effects of KT on single-leg CMJ performance and sEMG activity

A significant time effect was found on jump performance for the jump height ($p < 0.001$; $\eta_p^2 = 0.55$), jump power ($p = 0.006$; $\eta_p^2 = 0.2$), and jump mean velocity ($p = 0.003$; $\eta_p^2 = 0.19$) variables. Post-hoc Bonferroni comparisons revealed improvements on the jump height and jump power at 24 and 48 h, whereas the jump mean velocity only showed improvements at 24 h compared to the

▶ **Table 2** Between-group comparisons of means for electromyographic variables ($n = 24$).

Muscle	Outcome	Group	Baseline	Post 1 h	Post 24 h	Post 48 h	Time *p*-value (η_p^2)	Time × group *p*-value (η_p^2)
RF	Mean %EMG$_{max}$	KT	6.60 (1.2)	7.81 (1.9)	8.25 (1.5)	8.53 (1.2)	**0.006 (0.17)**	0.302 (0.05)
		Sham	7.35 (2.1)	7.23 (1.2)	8.00 (1.1)	8.00 (1.8)		
	iEMG	KT	17.2 (4.5)	17.7 (4.5)	16.7 (2.3)	16.9 (3.4)	0.842 (0.01)	0.583 (0.03)
		Sham	16.0 (4.6)	15.3 (2.5)	16.4 (2.3)	14.9 (2.8)		
VM	Mean %EMG$_{max}$	KT	6.48 (2.2)	7.01 (1.0)	8.59 (1.8)	8.87 (1.6)	**<0.001 (0.34)**	0.071 (0.1)
		Sham	7.10 (1.7)	7.10 (0.8)	7.77 (1.5)	7.9 (1.3)		
	iEMG	KT	16.3 (5.1)	16.3 (4.7)	17.1 (4.6)	17.6 (3.9)	0.307 (0.05)	0.960 (0.01)
		Sham	15.3 (4.1)	15.5 (1.9)	16.6 (3.9)	16.3 (4.6)		
BF	Mean %EMG$_{max}$	KT	4.23 (1.0)	4.6 (1.4)	5.78 (1.6)	7.42 (2.1)	**<0.001 (0.53)**	0.934 (0.01)
		Sham	4.74 (1.7)	5.25 (2.0)	6.02 (2.2)	7.64 (2.4)		
	iEMG	KT	10.6 (2.3)	10.6 (3.5)	11.3 (3.2)	14.5 (3.5)	**<0.001 (0.37)**	0.551 (0.03)
		Sham	10.0 (2.7)	11.1 (3.8)	12.4 (4.0)	14.0 (3.8)		
LG	Mean %EMG$_{max}$	KT	6.29 (1.6)	7.07 (1.4)	7.74 (1.8)	8.20 (1.2)	**<0.001 (0.35)**	0.113 (0.09)
		Sham	6.75 (1.8)	6.19 (1.6)	7.27 (1.4)	7.66 (1.4)		
	iEMG	KT	15.1 (2.6)	16.0 (2.8)	15.5 (3.2)	16.8 (2.2)	0.289 (0.05)	0.239 (0.06)
		Sham	13.9 (2.9)	13.4 (2.6)	14.8 (3.1)	14.3 (2.5)		

Abbreviations: BF, biceps femoris; iEMG, integrated electromyography; KT, Kinesio taping; LG, lateral gastrocnemius; η_p^2, partial eta-squared; RF, rectus femoris; VM, vastus medialis.

Note: Data are reported as mean (standard deviation), otherwise specified. The statistical significance at an alpha level 0.05 is represented by bold numbers.

baseline (▶ **Fig. 3**). However, no time-by-group interaction effect was observed ($p > 0.05$).

When muscular activity was expressed as mean %EMG$_{max}$, a significant time effect was found for all muscles analyzed ($p < 0.05$). Post-hoc Bonferroni comparisons revealed an increase in sEMG activity at 24 and 48 h compared to the baseline for all muscles analyzed. However, when sEMG activity was expressed as iEMG values, a significant time effect was found only for BF at 48 h ($p < 0.001$). Regardless the way of muscular activity calculation, no time-by-group interaction effect was observed for any of the muscles analyzed (▶ **Table 2**).

Effects of KT on muscle fatigue

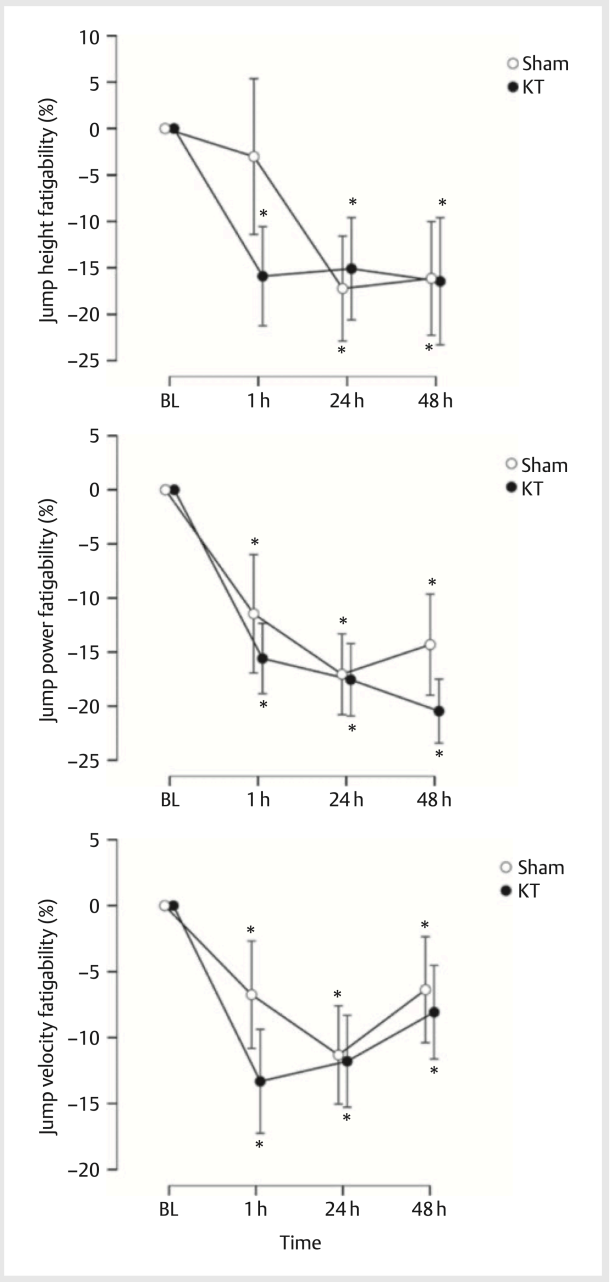
The muscle fatigue protocol (RCMJ$_{30}$) was repeated three times, after 1 (Day 1), 24 (Day 2), and 48 h (Day 3) of the KT application. Our results showed a significant decline in the jump height ($p < 0.001$; $\eta_p^2 = 0.4$), jump power ($p < 0.006$; $\eta_p^2 = 0.66$), and jump mean velocity ($p < 0.001$; $\eta_p^2 = 0.49$) variables after the muscle fatigue protocol. No time-by-group interaction effect was observed, except for the jump height ($p < 0.039$; $\eta_p^2 = 0.12$). However, after Bonferroni correction, no significant between-group differences were detected for the jump height at any time point ($p > 0.05$). The mean decrease in performance on the jump height, jump power, and jump mean velocity for both groups are shown in ▶ **Fig. 4**.

Discussion

This sham-controlled trial aimed to evaluate the effects of KT application on jumping performance at multiple time points (i.e., 1, 24, and 48 h postapplication) in both resting and fatigued states in trained female athletes. In contrast to our initial hypothesis, the study findings indicated that the KT group did not demonstrate significant improvements in single-leg CMJ performance or sEMG activity of the RF, VM, BF, and LG muscles over time, compared to the sham tape group, both in resting and fatigued states. These results suggest that KT treatment may not serve as an effective ergogenic aid for enhancing muscle performance for competitive female athletes in the short-term.

Effects of KT on athletic performance (resting state)

Previous studies have examined the acute effects of KT on multiple outcomes of athletic performance such as vertical and horizontal jumps, sprint performance, proprioception, muscle strength and power. Alabbad and Muaidi [31] showed a significant effect of KT on the horizontal jump distance (~0.08 m), but not on the vertical jump height or power compared to the sham tape in elite weightlifters. Similarly, Abellán et al. [32] reported statistically significant improvements in sprint performance (~0.08 s) in the KT group when compared to the no-tape group, but no differences were found on the vertical jump height in soccer players. Additionally, in a recent study, KT was observed to acutely enhance the dorsiflexion muscle strength by ~0.4 N in male handball players and ankle proprioception; yet, no differences were noted in balance, horizontal jump, or functional movement parameters [33]. A recent systematic review and meta-analysis examining the effects of KT on athletic performance and ankle functions in athletes with chronic ankle instability found only 9 favorable outcomes out of 60 analyzed [34]. Taken together, these studies suggest that KT may offer some benefits for specific aspects of athletic performance, but the overall evidence remains inconclusive and often conflicting,



▶ **Fig. 4** Time effect and time-by-group comparisons for muscle fatigability variables. Data are expressed as the percentage of change from the BL to the KT group. Error bars represent the 95 % confidence interval. Post hoc Bonferroni comparisons revealed differences statistically significant compared to BL (*). BL, baseline; KT, Kinesio taping.

leaving its true efficacy in question. Nevertheless, the validity of results from KT studies can be compromised if multiple hypotheses are tested without applying an appropriate multiple comparison procedure. Notably, none of these studies adjusted the type I error for multiple comparisons, which could result in misleading conclusions, especially when relying on *p*-value dichotomy [35]. For instance, when performing multiple hypothesis testing between two groups and twenty outcomes [33], the probability of having *p*-value < 0.05 by chance for one of the outcomes is 64.2 %. This concern is crucial when conducting multiple comparison analyses. Furthermore, researchers should interpret their findings based not only on statistical significance but also on the magnitude of KT effects. While even minor enhancements in muscle performance may hold significance for elite athletes striving for excellence, it is imperative to acknowledge that some reported improvements may not surpass inherent measurement errors in repeated measures, potentially lacking clinical relevance [36]. Our results are in line with these findings. Although the effects of KT on the single-leg CMJ and EMG activity exhibited a tendency to increase over time (particularly after 24 and 48 h), there were no differences between groups. Moreover, the maximum improvements observed in both groups over time was ~ 2.9 cm on average, which might fall within the range of variation between repeated measurements (coefficient of variation ~12 %) [3]. To our knowledge, the minimal detectable difference (i.e., the smallest change exceeding expected variability or measurement error) for the single-leg CMJ height has not been reported in the literature. However, the minimal detectable difference for the bilateral CMJ in trained female athletes has been reported as 3 cm [37]. Given that the observed improvement of 2.9 cm in the KT group falls just below this threshold, and considering that variability in the unilateral (single-leg) CMJ height is generally higher than in the bilateral CMJ, we believe that this change is more likely attributable to inherent measurement variability rather than a true intervention effect or a learning effect due to insufficient familiarization. Nonetheless, the consistent, albeit non-significant, trend toward better performance in the KT group across all jumping performance measures highlights the need for further research using a broader range of muscle groups and alternative KT techniques and tensions.

Similar to our study, some authors explored the effects of KT using various time intervals (i.e., application from 24 to 72 h), as positive effects may manifest after a potential adaptation period. Sheikhi et al. [38] reported no significant effect of tuck jump performance immediately after application, 24 and 72 h later, in competitive male athletes. This conclusion is supported by the absence of group differences observed across conditions of KT application (i.e., no stretch, approximately 50 % stretch, and 75 % stretch). KT did not enhance the 20-meter sprint performance but maintained muscle flexibility in healthy women university students after 48 h of taping [39]. Kanik et al. [40] found no changes in maximal quadriceps isometric strength and vertical jump height following an intense exercise protocol over the 72-h period of KT application, compared to the sham group. It is important to note that participants in this study were non-athletic adults, and thus, these findings may not be applicable to sport-specific settings. We extend this observation to a group of female athletes showing no differences between KT and sham application at any time points. A systematic review analyzing 193 comparisons of KT's effects on athletic performance outcomes found significant benefits only when compared to no tape, while no significant differences were observed when compared to sham tape across various metrics including vertical and horizontal jumps, sprint, distance running, agility, and dynamic balance [14]. These results highlight the importance

of appropriate study design, including the use of a sham group, to elucidate the potential benefits of KT on athletic performance.

Effects of KT on sEMG activation (resting state)

Beyond outcomes of athletic performance, sEMG may help understand subtle changes in muscle activation, even when these changes may not result in visible alterations in motor performance. KT has the potential to increase motor unit excitability and activate the muscle spindle reflex, which plays a crucial role in improving the muscular function, strength, and coordination during athletic performance [41]. However, it is worth noting that while these physiological effects are observed, they did not consistently translate into positive performance improvements in the studies. Rogan and Baur [42] reported that KT did not modify the superficial femoral region and calf muscles during the drop jump in men and women adults. Additionally, KT and sham tape applications did not improve the sEMG activity of the gastrocnemius, tibialis anterior, and soleus muscles during vertical jumping in non-athletic individuals [2]. Despite these findings suggesting that KT had no significant effect on muscle activity, it still holds promise for potentially enhancing muscle activity in trained adults, given their heightened readiness to perform muscle tasks. Indeed, there is a scarcity of research exploring the effect of KT on sEMG activation in trained population. Our study failed to identify significant effects of KT on sEMG activity in the RF, VM, BF, and LG during single-leg CMJ performance in trained female athletes, mirroring the outcomes observed in jumping performance.

As previously discussed, variations in study designs investigating the effects of KT on athletic performance may result in diverse implications for the outcomes. In a single-group pre–post test design study, KT application has been suggested to potentially enhance neuromuscular activity in specific muscles (i.e., gluteus maximus, BF, RF, gastrocnemius medialis, and longissimus) after 72 h in male athletes [26]. Interestingly, we observed enhancements in sEMG activity (mean $\%EMG_{max}$) of RF, VM, BF, and LG in both the KT and sham tape groups over time. These findings, which align with the improvements in single-leg CMJ performance that showed no between-group differences, derived from a randomized and single-blinded study, actually suggest the ineffectiveness of KT on neuromuscular activity. This highlights the need for further research to better understand its mechanisms and overall effectiveness. The varying outcomes found in the literature, largely contingent upon study design, highlight the difficulty in interpreting the impact of KT on neuromuscular activity, particularly during an athletic task. Overall, recognizing that the jump height, a reliable metric of jumping performance in scientific research, is linked to neuromuscular control rather than mere muscle activation, sEMG activity may not directly explain differences in jumping performance. Hence, the complexities of these interactions should be thoroughly considered when interpreting the effects of KT on athletic performance.

Effects of KT on muscle fatigue

Muscle fatigue has been extensively studied in athletic settings; however, there remains a gap in understanding the potential effects of KT on muscle fatigue. In our study, the effect of KT on single-leg CMJ performance was examined at multiple time points (i.e., 1, 24, and 48 h postapplication), under acute neuromuscular fatigue induced by $RCMJ_{30}$. This approach offers valuable insights into the potential acute and sustained impacts of KT on jumping performance, providing a more nuanced understanding of its effects across different time frames compared to studies that primarily investigate immediate effects. In fact, acute neuromuscular fatigue protocols, which involve repetitive stretch-shortening cycle movements, result in reductions in jumping performance and neuromuscular activity [43]. We demonstrated that single-leg CMJ performance decreased after $RCMJ_{30}$ in both KT and sham tape groups compared to the resting state at each time point. However, we did not observe a time-by-group interaction effect (▶ **Fig. 4**). Based on these findings, it is conceivable that KT had no substantial effect on muscle fatigue. This assertion finds support in a meta-analysis indicating insufficient evidence regarding the effect of KT on functional performance among individuals with particular musculoskeletal conditions, such as muscle fatigue [44]. Several studies exploring the impact of KT on muscle fatigue across different fatigue protocols have similarly reported no significant effect attributed to its application in both males and females [16–19, 45, 46]. These findings also indicate that the ineffectiveness of KT remains consistent regardless of the change in fatigue protocol used.

In contrast, some studies have demonstrated the effectiveness of KT on muscle fatigue [47, 48]. A recent randomized controlled trial showed that KT application on the calf muscles increased fatigue resistance during the heel rises test in college female athletes [49]. However, the authors cautioned that the interpretation of these results should consider the scope of the heel rises test, as muscle fatigue can vary depending on the protocol used. KT also resulted in increased peak torque of the quadriceps muscles in healthy male university students following an isokinetic fatigue protocol, although this study lacked a placebo or control group [50]. It is of note that biological sex is a potential variable that may affect muscle fatigue during intense exercises [51]. The observed lack of ergogenic effectiveness of KT on muscle fatigue in our study may be linked to our sample exclusively composed by trained female athletes. Therefore, analyzing the influence of KT on muscle fatigue while accounting for these sex-based differences becomes crucial. Moreover, our sample was not highly competitive, and we aimed to avoid a strong focus on any particular sport, making our findings more applicable to the general female athletic population. Future studies should replicate our results within specific sports. To achieve a comprehensive understanding of how KT impacts muscle fatigue in athletic settings, it is imperative to factor in additional elements like fitness level, nutrition, hydration, sleep quality, and individual physiological differences [52].

The primary limitation of our study is the sample size. However, while a larger sample size might have amplified the discernibility of KT's impact from a statistical standpoint, particularly considering its potential cumulative effect over time, the observed differences between groups were negligible. For example, the variance in jump height performance between the KT and sham tape groups was at most 1.6 cm. Consequently, an increase in statistical power would likely not have altered the conclusions of this study. Furthermore, we did not measure the activation of all muscle groups involved in the single-leg jump due to practical constraints and because the focus of the study was on specific muscle groups. Despite

including premenstrual or menstrual phases as inclusion criteria, slight changes in menstrual cycle phases could still be expected. The absence of a follow-up phase also limits our ability to assess the long-term effects and durability of KT, which would be important for understanding its sustained impact. Finally, while this study did not explore other common taping techniques like facilitation, these techniques could potentially provide further insights. However, most studies comparing facilitation and inhibition techniques have reported no significant differences in their effects [10, 53].

Conclusion

Our study showed that the KT had no effect on single-leg CMJ performance and sEMG activation of the RF, VM, BF, and LG muscles. Similarly, we did not find evidence to support the idea that KT mitigates the deleterious effects of acute neuromuscular fatigue during single-leg CMJ performance. The observed changes in jumping performance and sEMG activation variables over time in both KT and sham tape groups, along with the lack of significant differences between groups, may be influenced by the psychological effects of KT treatment. Future research should explore a broader range of muscle groups and alternative KT application techniques to better understand the potential benefits and mechanisms of KT in enhancing neuromuscular functions under resting and fatigued states.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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