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Kinesiology taping and lower limb muscle activation: a systematic review and meta-analysis in athletes and healthy adults

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Abstract

Introduction. Kinesiology taping (KT) is frequently applied in sports and rehabilitation settings to influence muscle activation and enhance performance. However, its effectiveness remains inconclusive, especially among healthy individuals and athletes. Aim of Study. This systematic review and meta-analysis aimed to synthesize current evidence on the effects of KT – including both facilitatory and inhibitory techniques – on lower limb muscle activation. Material and Methods. A comprehensive search was conducted across six electronic databases (Cochrane CENTRAL, Web of Science, Scopus, MEDLINE, PubMed, and PEDro) from inception to December 2023. Randomized controlled trials (RCTs) evaluating the effects of KT on surface electromyographic (sEMG) outcomes – including muscle activation amplitude (e.g., root mean square, percentage of maximum voluntary isometric contraction) and activation duration (onset/offset timing) – in lower limb muscles (e.g., gastrocnemius, rectus femoris, vastus medialis, vastus lateralis, gluteus medius) were included. Risk of bias was assessed, and the GRADE approach was used to evaluate the certainty of evidence. Results. Ten RCTs comprising 356 participants (162 athletes, 194 healthy adults) met the inclusion criteria. These included two-arm, three-arm, and crossover designs, reflecting diverse experimental methodologies; three trials were eligible for meta-analysis. The studies employed two-arm, three-arm, and crossover designs, with KT durations ranging from immediate application to 72 hours. Six studies reported increased muscle activation following KT, including unexpected enhancements from inhibitory KT (IKT). Meta-analysis of three RCTs showed a small, statistically nonsignificant effect of IKT on lower limb muscle activation compared to control (standardized mean difference [SMD] = 0.20; 95% CI: –0.20 to 0.59; I^2 = 0%, p = 0.33). Limitations. Heterogeneity in taping protocols, participant populations, and limited blinding mayaffect the generalizability and certainty of the findings. Conclusions. While individual studies suggest that KT may enhance muscle activation – particularly when applied in a facilitatory manner over extended durations – the overall evidence remains inconsistent. Meta-analysis revealed a small, statistically nonsignificant effect of IKT, indicating that its clinical efficacy in improving muscle activation, as measured by surface electromyography, remains uncertain and context-dependent. Further high-quality, standardized research is warranted.

KEYWORDS: healthy volunteers, athletes, surface electromyography, sports rehabilitation, injury prevention.

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Introduction

Physical fitness is a cornerstone for both competitive athletes and healthy adults, forming the foundation for optimal health, well-being, and functional performance in daily activities [1, 2]. Improved physical fitness is essential for superior muscle activity and athletic performance, whether it is for elite athletes seeking peak performance or healthy individuals aiming to maintain

well-being and prevent injuries [3]. Conversely, a decline in fitness compromises performance and increases the risk of injuries [4]. Muscular strength, a key component of physical fitness, relates to the ability of muscle to generate force [5]. Electromyography (EMG) analysis provides valuable insights into muscle activation, helping to optimize performance, reduce sports injuries, and promote musculoskeletal health [6]. Kinesiology taping (KT), a widely used technique in clinical and athletic rehabilitation, involves the application of elastic tapes designed to enhance neuromuscular function and skin tissue recovery [7, 8]. Its popularity surged following its adoption by athletes during the 2008 Olympic Games [7]. KT is composed of elastic polymer materials and can be applied to facilitate or inhibit muscle activation depending on the taping direction. Facilitatory kinesio taping (FKT) is applied from muscle origin to insertion, aiming to enhance muscle contraction, while inhibitory kinesio taping (IKT) is applied in the opposite direction to reduce muscle activation [9-11].

The mechanisms underlying these effects are thought to involve the interaction of KT with fascia and mechanoreceptors. In FKT, the recoil force of the tape aligns with the direction of muscle contraction, potentially aiding activation. Conversely, the opposing pull of IKT may stretch the Golgi tendon organs, inhibiting muscle activation [11, 12]. Additionally, FKT may increase motor unit excitability through stimulation of cutaneous mechanoreceptors and elicitation of a muscle spindle reflex, while the force of IKT may dampen contractions [11, 12].

KT is a non-invasive, cost-effective, and time-efficient intervention that offers a practical alternative to many traditional therapeutic techniques. It is simple to apply, painless, and well-tolerated by most individuals, making it particularly appealing in sports and rehabilitation settings [13]. Compared to rigid athletic tape, KT can stretch up to 140% of its original length, mimicking the natural elasticity of human skin. This unique elastic property allows KT to recoil after application, microscopically lifting the skin, which may reduce local discomfort and facilitate lymphatic flow [14]. Furthermore, KT is reported to provide functional support to muscles and joints without restricting range of motion, and may assist in neuromuscular reeducation and rehabilitation processes [13, 14]. Despite these advantages, KT is not without limitations. One of the most frequently reported concerns is skin irritation following prolonged use. These dermatological reactions may arise not only from allergic responses to the adhesive but also from moisture accumulation due to sweating during regular activity [15]. Additionally, dense body hair can impair the adhesion of the tape, reducing its therapeutic efficacy. Another important consideration is that KT is not designed for joint immobilization, limiting its utility in injuries that require rigid stabilization [15].

Despite widespread use of KT, its efficacy in enhancing muscle activity and performance remains contentious [16]. Studies such as those by Huang et al. [17] report positive effects on muscle activation, while a systematic review and meta-analysis by Nunes et al. [18] highlight mixed results, with many studies finding no significant difference between KT and placebo treatments [19, 20]. This inconsistency in the literature highlights the necessity for further investigation into the efficacy of KT on muscle activation.

Aim of Study

The present systematic review and meta-analysis aim to synthesize current evidence regarding the impact of KT on lower limb muscle activation in healthy adults and athletes, thereby addressing a critical gap in sports rehabilitation research. The findings of this review have important clinical implications: they may aid clinicians in making evidence-based decisions regarding the therapeutic use of KT, guide researchers in identifying methodological limitations and areas for future exploration, and inform patients and athletes about the realistic benefits and constraints of KT as a supportive intervention for neuromuscular function.

Methods

Registration and protocol amendments

The present systematic review and meta-analysis are reported as per the recommendations of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [21]. The review has been registered in the International Prospective Register of Systematic Review (PROSPERO) under registration number CRD42023397303.

During the review process, we encountered incomplete or missing data for certain planned outcomes in several studies. Specifically, while muscle activation via surface electromyography (sEMG) was consistently reported, some studies did not provide sufficient numerical data (e.g., mean and standard deviation) to allow for inclusion in the meta-analysis. As a result, these outcomes were excluded from the quantitative synthesis. However, they were retained in the qualitative synthesis and discussed

narratively. No other changes to the originally registered protocol (PROSPERO CRD42023397303) were made.

Search strategy

The search strategy for identifying relevant literature on the effect of athletic or kinesiology tape on electromyographic outcomes in athletes and healthy individuals involved a comprehensive and systematic approach. Initially, a wide-ranging database search was conducted encompassing key databases like Cochrane Central Register of Control Trials (CENTRAL), Web of Science (WoS), Scopus, MEDLINE, PubMed, and the Physiotherapy Evidence Database (PEDro), ensuring a broad capture of potentially relevant studies. The search was meticulously designed to include studies involving human subjects, with a focus on peer-reviewed articles published in English, without restrictions on the publication year. This allowed for the inclusion of all relevant studies from the inception of databases up to December 2023, thus encompassing a comprehensive time frame that would likely capture the evolution and breadth of research in this area.

To precisely target the research question, a combination of key terms related to athletic tape and electromyography were utilized, employing Boolean operators "AND" and "OR" to refine the search. The MeSH keywords used for article searches were "Athletic Tape" and "Electromyography". To conduct an extensive search we included variations and synonyms of "Athletic Tape" (e.g., "Kinesio Tape," "Kinesiotape," "kinesiology tape," "KT tape," "Kinesio taping," "Orthotic Tape") and "Electromyography" (e.g., "Electromyographies," "Surface Electromyography," "Surface Electromyographic," "Electromyogram"), coupled with terms related to athletic performance measures like "Vertical Jump" and participant characteristics (e.g., "Athletes," "Elite Athlete," "Professional Athlete," "College Athletes," "Healthy Adults," "Healthy Volunteers").

The integrity and appropriateness of search strategy were verified by two authors (AR and SZ), who independently checked the terms in each database. Following the initial search, all identified articles were exported to EndNote™ Desktop version 21 (Clarivate Plc, Philadelphia, USA), a reference management tool, where duplicates were systematically identified and removed to avoid redundancy in the review process. Subsequently, the remaining studies underwent a rigorous screening process. Initially, titles and abstracts were carefully reviewed by the authors to determine in accordance with predefined inclusion criteria the eligibility of each study. This step served to exclude irrelevant or non-applicable studies efficiently. Articles that passed this initial screening were then subjected to a full-text review to assess their suitability for inclusion in the review comprehensively. This multistep process ensured a thorough and systematic evaluation of the literature, identifying the most relevant and high-quality studies for inclusion in the analysis.

Eligibility criteria

The PICO (Populations, Interventions, Comparators, and Outcome) criteria were applied to identify eligible articles [22]. The question of the present review is whether KT (intervention) is effective in muscle activation (outcome measure) in athletes and healthy adults (population) when compared with a control group (comparator). The inclusion criteria for articles selected for review are: (1) the age group of the participants between 18 to 32 years, (2) no clinical diagnosis of any lower limb pathology, (3) randomized controlled trials (RCTs; crossover trial included), and (4) articles on muscle activation of lower limb muscles as the primary outcome measure. The exclusion criteria were the following: (1) studies that did not meet the applied PICO criteria for review, (2) case reports, cross-sectional trials, longitudinal studies, (3) cohort studies, (4) ongoing studies, (5) case series, (6) literature reviews, (7) thesis and (8) clinical trial with no control group.

Reviewer agreement and discrepancy resolution

Data extraction and study selection were independently conducted by two reviewers (AR and SZ), with all extracted data cross-verified to ensure accuracy. Any disagreements were resolved through discussion with a third reviewer (TZ). Based on the observed reviewer decisions during full-text screening, the interrater agreement was calculated using Cohen's kappa, which yielded a value of $\kappa = 0.70$, indicating substantial agreement between reviewers.

For methodological transparency, we further clarify that data extraction followed a structured template that included study characteristics (author, year, population, intervention details, comparator, outcomes, and follow-up), numerical outcome data (mean, SD, sample size, and effect estimates), and risk of bias assessments. Each reviewer performed data extraction independently to minimize bias. Discrepancies in extracted values (e.g., numerical differences or interpretation of outcome reporting) were discussed, and consensus was reached with input from a third reviewer when required. This

multistep approach ensured consistency and reliability of the extracted dataset, which formed the basis for both qualitative synthesis and meta-analysis.

Risk of bias assessment

To rigorously evaluate the methodological quality and risk of bias within the included studies, a dual-assessment approach was adopted, leveraging both the PEDro scale and the Cochrane risk of bias-2 (RoB 2) tool. This comprehensive assessment strategy ensured a robust examination of internal validity and bias levels of the studies.

The PEDro scale, a widely recognized tool for assessing the methodological quality of RCTs, comprises a 10-item scoring system. Each item on the scale critically examines various aspects of study design and execution to gauge internal validity. According to established criteria, studies achieving a score above 6 out of 10 on the PEDro scale were classified as high-quality, indicating a lower risk of bias and a higher level of evidence reliability [23]. To undertake this assessment, two independent reviewers (AR and TZ) meticulously scored each study according to the PEDro criteria. Subsequent to their independent evaluations, the reviewers convened with a third expert (SZ) to discuss and reconcile any differences in their assessments. This collaborative approach ensured a balanced and comprehensive evaluation, culminating in a consensus on methodological quality of each study.

Certainty of evidence

In this systematic review, the certainty of the evidence was thoroughly evaluated through the development of summary of findings (SoF) tables, a process initially undertaken by two independent authors (AR and TZ). Any discrepancies in their assessments were resolved by consulting a third author (MFA), ensuring a unified approach. The appraisal of evidence certainty was conducted using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system, which scrutinizes five key domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias. These domains directly influence the confidence in the evidence and, consequently, the strength of healthcare recommendations. The GRADE system, facilitated by the GRADEpro guideline development tool, provides a structured and transparent method for assessing the quality of evidence, distinguishing it into four levels of certainty: high, moderate, low, or very low [24].

This structured evaluation process, pivotal for the systematic review, ensured that the evidence presented was rigorously analyzed and categorized. By employing the GRADE system, the review highlights the reliability and applicability of the findings, contributing to informed clinical decision-making and guideline development. The methodology reflects a commitment to scientific integrity, offering a clear, standardized assessment of evidence quality that is essential for advancing healthcare practices and outcomes.

Statistical analysis

Endpoint data were extracted from the included studies for both intervention and control groups covering key outcome measures. Initial data points collected included the number of participants (n), mean, standard deviation, p-value, and 95% confidence intervals (CIs), when available. For further analysis, Review Manager (RevMan 5.4, provided by The Cochrane Collaboration) was utilized. A random effects model was applied to calculate the standardized mean differences (SMDs) and corresponding 95% CIs, accounting for potential methodological heterogeneity across studies. This approach is consistent with established guidelines for conducting meta-analyses [25]. The effect sizes were interpreted using SMD values, where 0.2 indicates a small effect, 0.2-0.5 represents a medium effect, and values greater than 0.5 reflect a large effect size, in accordance with Cohen's criteria [26]. The heterogeneity among studies was assessed using the I^2 statistic, where heterogeneity is interpreted as low (0-40%), moderate (30-60%), high (50-90%), and very high (75-100%), ensuring a comprehensive evaluation of variability among study findings [25]. A value of $p < 0.05$ was considered statistically significant. This methodological approach ensures a robust analysis of the treatment effects of KT on the muscle activation, facilitating a comprehensive understanding of its efficacy and applicability in injury prevention. In instances of missing data from included studies, attempts were made to contact the trial authors to acquire the necessary details. Studies that failed to report mean change and SD or lacked sufficient information for these calculations were excluded from the meta-analysis.

To assess the potential for publication bias, a funnel plot was constructed using the effect size (SMD) and standard error from each included study. In addition to visual inspection, two statistical methods were used: Egger's linear regression test and Begg's rank correlation test. These tests quantitatively assessed funnel plot asymmetry and the presence of small-study effects. The publication bias analyses were conducted using MedCalc statistical software version 22.009

(64-bit) (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org).

Results

Search outcomes

The search method initially identified 817 publications across the databases. A total of 112 articles were retrieved from CENTRAL, 191 from WoS, 73 from Scopus, 76 from MEDLINE, 282 from PubMed, and 83 from PEDro. After removing 333 duplicates, 377 papers were assessed first by title, and then by abstract. A total of 292 studies were eliminated because of the following reasons: (1) they were not explicitly related to athletes or healthy participants; (2) KT was not the primary intervention, and (3) lower limb muscle activation was not assessed in the study. A total of 43 studies were identified for full-text analyses. After a comprehensive evaluation in full-text, ten articles were deemed eligible for inclusion in the present review (Figure 1). The search was performed by three authors independently (AR, SZ and TZ) and any conflict was resolved by discussion with a fourth author (SS) (Figure 1).

Studies characteristics

Of the included studies, four were two-arm RCTs [19, 27-29] and another four were three-arm RCTs [30-32]. One study was a two-arm crossover parallel group trial

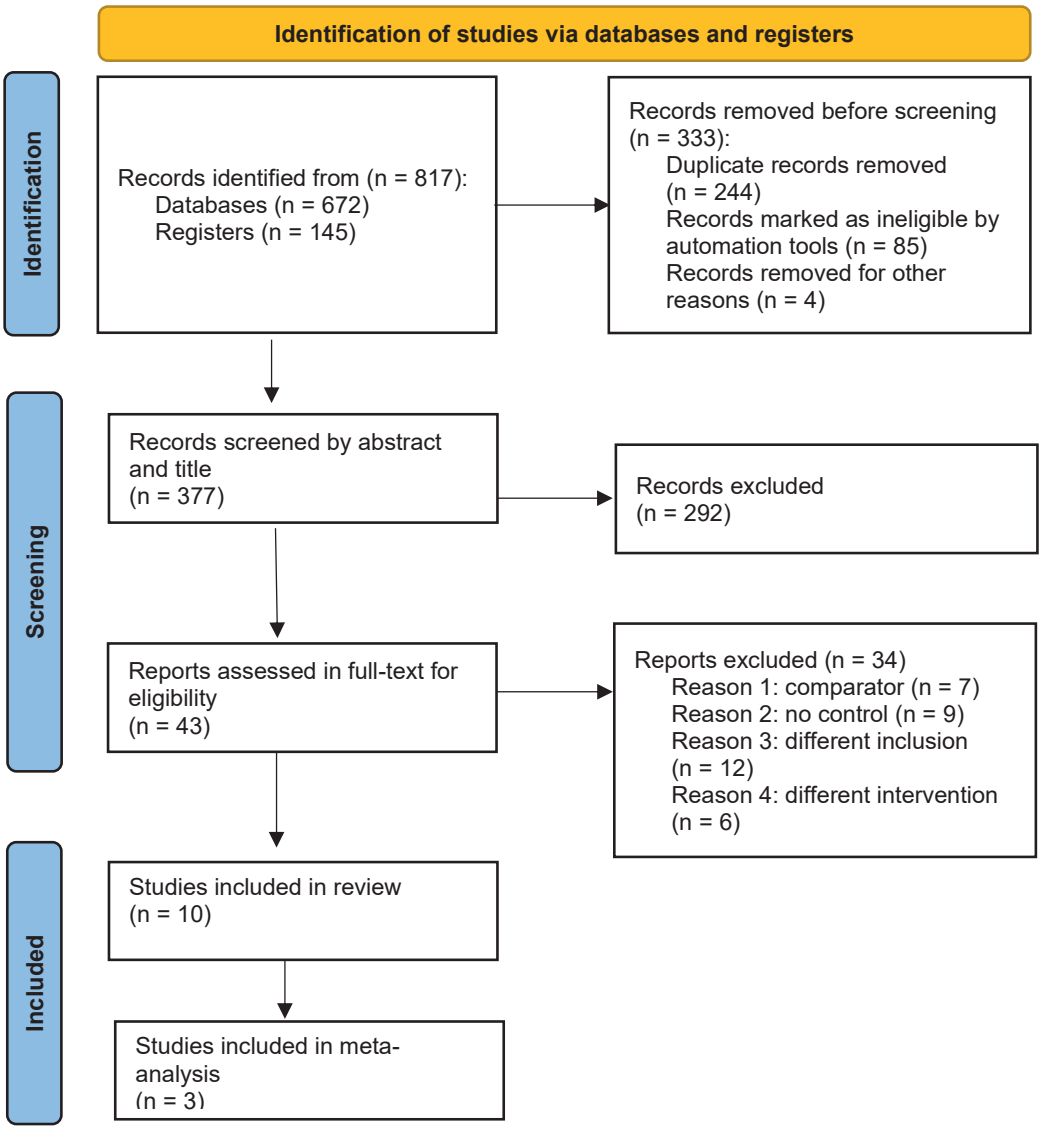

Figure 1. PRISMA flow chart

with unconfirmed randomization. The last study was a randomized controlled two-arm crossover trial [33].
The included studies featured a range of study designs, with the majority employing RCTs. Of the ten studies, four were two-arm RCTs [19, 28, 29, 33], and four were three-arm RCTs [30, 31]. Additionally, one study used a two-arm crossover trial [33], and one study employed a randomized controlled two-arm crossover trial [19]. The duration of KT application varied among studies: four studies applied KT for immediate effects, assessing muscle activation directly after tape application [17, 29-31]. Three studies applied KT for 24 hours [19, 28, 33], while one study extended the KT application for 48 hours [32] and two studies for 72 hours [33, 34].
The settings of the studies were varied, with participants recruited from different athletic populations. For example, athletes were recruited from basketball, volleyball, soccer, and handball teams in various studies [19, 28-30], while others included healthy adults without any clinical diagnosis of lower limb pathology. The age range of participants was typically 20-30 years, representing both male and female individuals, and their physical activity levels varied according to the sports they participated in. These studies were primarily conducted in sports rehabilitation clinics or academic settings, reflecting a blend of clinical and sports environments that enhances the generalizability of the findings across both athletic and non-athletic populations.

Participants
Ten studies included a total of 356 individuals, of which 162 participants were athletes and 194 participants were healthy adults. The participants in the included studies were recruited as follows: from basketball and volleyball teams in one study [29], from soccer, basketball and handball teams in another study [30], from a soccer team in one study [19] and from a volleyball team in another [27]. The total numbers of male and female participants were 212 and 144, respectively. Three studies recruited only male subjects [19, 30, 31], while one study only recruited female participants [29]. The rest of the six studies recruited both male and female participants [17, 27, 28, 32, 33]. The age of all the subjects in the included studies was in the range of 20 to 30 years (Table 1).

Table 1. Characteristics of eligible studies for review

Study	Participants description	Study design	Intervention	Control	Outcome measures	Key findings
Raza et al. 2023 [34]	48 (35 male athletes, 13 female)	three-arm RCT	FKT to LG at 50% of its tension IKT to LG at 15% of its tension	no KT, daily routine training	motoneuron excitability EMG activity of LG countermovement jump height	% MVIC ↑ in group A only (Mmax) in group A and B ↑ CMJ height group A and B ↑
Sinaei et al. 2021 [29]	32 female athletes mean age 26.33 ± 5.93 yr VMO FKT (n = 16) VL IKT (n = 16)	two-arm randomized clinical trial	VMO was taped with FKT at 25% of its tension VL was taped with IKT at 15% of its tension	inhibitory KT	EMG activities of the VMO VL Star Excursion Balance Test (mSEBT) VAS	VMO amplitude ↑ VL amplitude ↓ composite reach distance of the balance test ↑ pain intensity ↓
Huang et al. 2011 [17]	31 healthy adults (19 males and 12 females) mean age 25.3 ± 3.8 yr	crossover two-arm parallel group	Y-shaped KT was applied to MG and LG in the direction of insertion to origin	placebo tape	EMG activities of LG and MG VGRF vertical jump height	in group A, EMG activities of MG ↑ and VGRF ↑ no significant differences in jump height in group A no change in EMG activity of all testing muscles and VGRF in group B; however, the height of the jump ↓

Zaworski et al. 2022 [32]	90 healthy students mean age 21.79 ± 0.94 yr KT (*n* = 30, 18 females, 12 males) RT (*n* = 30, 18 females, 12 males) placebo tape (*n* = 30, 14 females, 16 males)	three-arm RCT	I-shaped KT was applied to the posterior iliac and GT for GMed muscle at 50% tension, for 48h The same procedure was used for group 2	placebo tape	EMG activities of GMed during glute bridge unilateral glute bridge clamshell pelvic drop lunge	GMed activation ↑ in all groups in all exercises significant difference after 48 h only seen in glute bridge in KT and RT groups
Briem et al. 2011 [30]	30 healthy male athletes mean age 24.5 ± 5.0 yr (*n* = 15, less stable) (*n* = 15, more stable)	three-arm RCT	KT was applied in a single strip, from origin to insertion of the fibularis longus muscle; application for KT (nonelastic tape) was a common combination of stirrups, horseshoe strips, and heel-locks on same muscle	no tape	EMG activity of the fibularis muscle	KT did not alter muscle activity before, during, or after a sudden inversion perturbation significantly greater muscle activity was seen in nonelastic tape condition as compared to the untaped condition
Gómez-Soriano et al. 2013 [33]	19 healthy volunteers (8 males, 11 females) mean age 23.8 ± 3.9 yr	randomized controlled two-arm crossover trial	KT and sham tape were applied (for 24 h) from insertion to origin onto the gastrocnemius muscles of all subjects in two randomized sessions	sham tape	EMG activities of the gastrocnemius muscle	KT has no effect on healthy muscle tone, extensibility or strength; however, a short-term increase of gastrocnemius EMG activity after KT application
Dos Santos Glória et al. 2017 [19]	30 male soccer players allocated in 2 groups: KT group, *n* = 15, age 17 ± 0.9 yr placebo group, *n* = 15, age 16.5 ± 1.6 yr	two-arm RCT	KT was applied to the rectus femoris of dominant leg, from origin to insertion for 24 hours	placebo tape	EMG activities single leg hop test single leg triple hop test	no significant differences were found between groups for hop tests, RMS of the EMG signal or peak torque of the knee extensors or hop test distance
Martínez-Gramage et al. 2014 [28]	36 healthy subjects allocated in 2 groups: KT group, *n* = 18, age 21.8 ± 3, men/women 13/5 control group, *n* = 18, age 22.9 ± 4.3 yr, men/women 11/7	two-arm RCT	two strips (I- and Y-shaped inhibitory type) KT was applied to the gastrocnemius muscle at 15-25% tension for 72 h	no tape	mean amplitude of the LG sEMG signal during the stance phase duration of LG activity of each walking cycle	no significant change in amplitude significant ↓ in duration of LG
Halski et al. 2015 [27]	22 volleyball player allocated in 2 groups (8 men,14 women): KT group, *n* = 12, age 22.30 ± 1.88 yr PT group, *n* = 10, age 21.50 ± 2.07 yr	two-arm RCT	KT was applied to RF (facilitation technique) for 24 h	placebo adhesive tape	resting and functional sEMG activity of RF	resting sEMG activity for the RF muscle ↓ in both studied groups

Serrão et al. 2016 [31]	18 males with mean age 28.0 ± 6.7 yr	three-arm RCT	performed barbell back squat exercise with different conditions of taping: facilitation, inhibition on the quadriceps (BF, VL and VM)	placebo tape	magnitude of EMG activity of the vastus lateralis, vastus medialis, and biceps femoris	no changes were observed in magnitude of EMG in all the testing muscles

Note: RCT – randomized controlled trial, KT – kinesiology tape, FKT – facilitatory kinesio taping, RT – rigid tape, IKT – inhibitory kinesio taping, PT – placebo tape, EMG – electromyography, sEMG – surface electromyography, MVIC – maximum voluntary isometric contraction, Mmax – maximum motor response, VAS – visual analogue scale, GT – greater trochanter, GMed – gluteus medius, RMS – root mean square, RF – rectus femoris, LG – lateral gastrocnemius, MG – medial gastrocnemius, VMO – vastus medialis oblique, VL – vastus lateralis, VM – vastus medialis, BF – biceps femoris, VGRF – vertical ground reaction force, CMJ – countermovement jump

Interventions

All studies included KT as their primary intervention. KT was applied by two different techniques in the included studies: FKT and IKT. FKT was applied in the direction of the muscle origin to insertion in four of the ten studies [19, 27, 30, 32], while IKT was applied in the direction of insertion to the origin of muscles in three out of ten studies [17, 28, 33]. The rest of the three studies used both FKT and IKT techniques on the subjects [29, 31]. KT was applied for various durations in the included studies and the variables were assessed at different time points. Four of the ten studies have applied KT to see the immediate effects [17, 29-31]. Three studies have applied KT for 24 hours [19, 27, 33]. One study applied KT for 48 hours [32], while two studies applied KT for 72 hours [28].

The application of the taping strips was Y-shaped or I-shaped in the included studies. The Y-shaped KT strips were applied with 25% tension on the vastus medialis oblique and with 15% tension on the vastus lateralis in one included study [29]. In three included studies Y-shaped KT strip was applied on the gastrocnemius [17, 33], while in one included study Y-shaped KT was applied on the rectus femoris muscle [27]. In another study it was applied on the quadriceps [31]. The I-shaped KT was applied on the fibularis longus muscle in one study [33] and in another it was applied on the rectus femoris [19]. Both Y- and I-shaped KT strips were used only in one study at 15-25% tension in the gastrocnemius [28].

Outcome measures

In the included studies the effect of KT was assessed at the baseline and end of the intervention on muscle activation. All the included studies have examined the sEMG activity of lower limb muscles [17, 19, 27, 29-33]. sEMG showed high reliability (ICC_{mean} = 0.90; range 0.72-0.99) and high validity (*rho* = 0.92) in healthy participants [35]. The muscle activation was measured at different time points in the included studies. Four of the ten studies assessed the sEMG at the baseline and immediately after KT application [17, 29-31]. While two of the ten studies assessed sEMG at the baseline, immediately after KT application and after 24 hours of KT application [19, 33]. One study assessed sEMG at the baseline and after 24 hours of KT application [27]. Another study evaluated sEMG at the baseline and after 72 hours of KT application [28, 34].

Risk of bias in included studies

The risk of bias for the following domains is summarized in Figure 2 and Figure 3. The risk of bias was performed using RoB 2. Out of the ten studies, two were crossover trials and eight were RCTs, so we separately performed risk assessment for both designs. The intention-to-treat (ITT) analysis approach was employed in evaluating the studies, aligning with the research plan to investigate the impacts of KT on lower limb muscle activation.

Randomization process

The randomization process plays a pivotal role in minimizing selection bias in clinical trials. Among the ten included studies, six were assessed as having a low risk of bias, while four were categorized as having some concerns. Of these, two studies explicitly reported using random sequence generation methods [27, 28]. Furthermore, six studies described procedures for allocation concealment and were therefore judged to be at low risk of bias [19, 28, 32, 33]. In contrast, four studies did not report any method for allocation concealment and were classified as having an unclear risk of bias [17, 29-31].

Figure 2. Risk of bias assessment for selected studies using Cochrane's RoB 2 tool

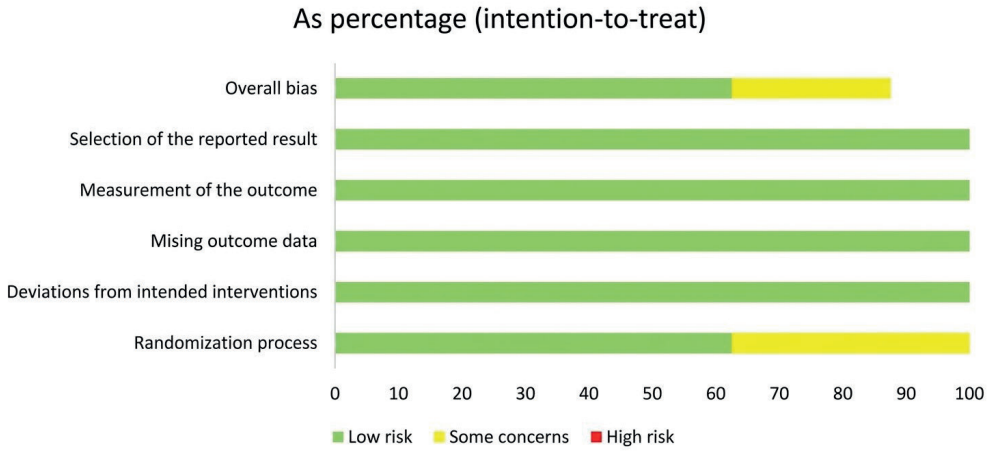

Figure 3. Risk of bias in percentage (RoB 2)

Deviations from intended interventions

This area assesses the consistency and adherence to the intervention protocols. Remarkably, all included studies showed a low risk of bias in this domain, suggesting that the interventions were delivered as planned.

Missing outcome data: The integrity of the results of the studies heavily relies on complete outcome data. In our review, all included studies were evaluated as low risk, indicating a comprehensive dataset was available for analysis.

Outcome measures: Ensuring that outcomes are measured in a consistent, reliable manner is crucial for valid conclusions. All studies in our review were assessed as low risk for this domain, which bolsters the credibility of the reported findings.

Selection of the reported result: The transparency with which results are reported affects the trustworthiness of the research. Our review found all studies to have a low risk of bias in reporting, underscoring a high level of transparency and accountability.

Overall bias: When considering the overall risk of bias, four studies were marked with some concerns primarily due to issues with randomization, allocation and concealment. Nevertheless, none of the studies were classified as having a high risk of bias, which speaks to the general quality and reliability of the included research.

PEDro quality assessment of study methodology

In this systematic review, the methodological quality of ten initially selected studies was evaluated using the PEDro scale, a rigorous tool designed to assess the validity and reliability of clinical trials. By scrutinizing key methodological aspects such as randomization, allocation concealment, and blinding of outcome assessors, the PEDro scale enabled the identification of studies with lower risk of bias. This critical evaluation step ensures the inclusion of only high-quality studies, thereby enhancing the overall reliability and validity of the review findings. Out of ten studies, one study scored nine [34], three studies scored eight [19, 27, 33], four

Table 2. Physiotherapy evidence database (PEDro) scale scores for each study

Variables	Eligibility criteria	Randomized allocation	Concealed allocation	Comparable at baseline	Blinding of subjects	Blinding of therapist	Blinding of assessors	Adequate follow-up	Intention to treat analysis	Comparison between groups	Point estimates and variability	Total score
Raza et al. 2023 [34]	1	1	1	1	1	0	1	1	1	1	1	9
Zaworski et al. 2022 [32]	1	1	1	1	1	0	0	1	0	1	1	7
Sinaei et al. 2021 [29]	1	0	0	1	0	0	1	1	1	1	1	6
Dos Santos Glória et al. 2017 [19]	1	1	1	1	1	0	1	1	0	1	1	8
Serrão et al. 2016 [31]	1	0	0	1	0	0	1	1	1	1	1	6
Halski et al. 2015 [27]	1	1	1	1	1	0	0	1	1	1	1	8
Martínez-Gramage et al. 2014 [28]	1	1	1	1	0	0	1	1	0	1	1	7
Gómez-Soriano et al. 2013 [33]	1	1	0	1	1	0	1	1	1	1	1	8
Briem et al. 2011 [30]	1	1	0	1	0	0	1	1	1	1	1	7
Huang et al. 2011 [17]	1	1	0	1	1	0	0	1	1	1	1	7

studies scored seven [17, 28, 30, 32] and two studies scored six [29, 31].

Studies included in this systematic review achieved an average PEDro score of 7.3, indicating a high level of methodological quality. This average underscores that the findings of the review are based on evidence from studies demonstrating a commendable degree of reliability and validity. The utilization of the PEDro scores serves as a benchmark for gauging the strength of presented evidence, where higher scores are indicative of more robust and credible findings. This assessment of methodological quality is essential not only for interpreting the outcomes of the review with confidence but also for guiding subsequent research efforts and clinical practices concerning the application of KT on lower leg muscle activation (Table 2).

Findings of certainty of evidence

The detailed analysis of the certainty of evidence using the GRADE approach for the outcomes measured in the

Table 3. Summary table of certainty of evidence

Certainty assessment							Summary of findings				
Participants (studies) follow-up	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Overall certainty of evidence	Study event rates (%)		Relative effect (95% CI)	Anticipated absolute effects	
							With control	With KT		Risk with control	Risk difference with KT
Muscle activation											
101 (3 RCTs)	not serious	not serious	not serious	not serious	none	⊕⊕⊕⊕ high	49	52	–	–	SMD 0.20 higher (–0.20 to 0.59 higher)

Note: KT – kinesiology tape, RCT – randomized controlled trial, CI – confidence interval, SMD – standardized mean difference

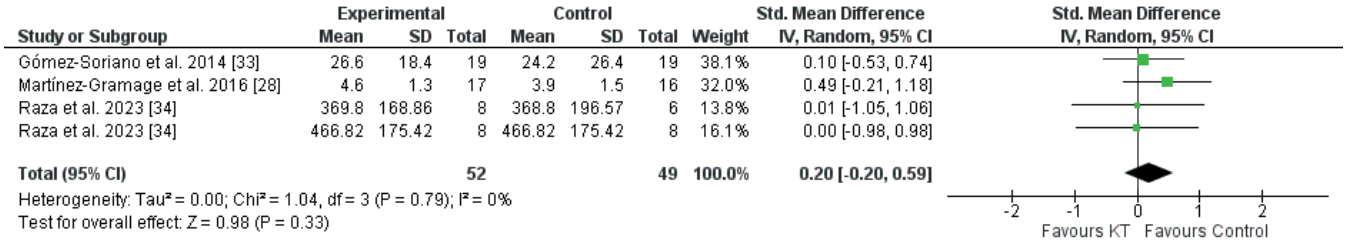

Figure 4. Forest plot of the effects of kinesiology taping on lower limb muscle activation

studies on KT reveals high certainty for the outcome. No serious concerns were noted across the domains of risk of bias, inconsistency, indirectness, imprecision, and publication bias, indicating high evidence quality. Overall, the evidence supports the effectiveness of KT for muscle activation, as shown in Table 3.

Effects of intervention

All ten studies have reported the muscle using EMG after KT intervention. The muscle activity following KT application has increased significantly in the five included studies [17, 28, 29, 32, 33]. One included study reported an increase in muscle activity of the vastus medialis oblique and vastus lateralis immediately after KT application [29]. Huang et al. [17] also reported significant increase in medial gastrocnemius muscle activity. Zaworski et al. [32] have reported an increase in muscle activity of the gluteus medius but significant difference was seen after 48 hours of KT application [32]. Gómez-Soriano et al. [33] have reported increased activity of the gastrocnemius muscle but for a short time. Martínez-Gramage et al. [28] have seen the effect of IKT and reported a decrease in the duration of lateral gastrocnemius EMG activity. Raza et al. [34] have reported that application of FKT increases muscle activity, while reduction in activity has been reported after IKT. Three studies have reported no significant change in muscle activity following KT application [19, 30, 31]. One study reported that EMG activity of the rectus femoris muscles decreased following FKT application [27].

Quantitative analysis

A meta-analysis was conducted using data from three RCTs that reported sufficient information for calculating SMD. The pooled estimate showed a small, statistically nonsignificant effect of KT on lower limb muscle activation compared to control (SMD = 0.20; 95% CI: −0.20 to 0.59; $p = 0.33$), with no observed heterogeneity ($I^2 = 0\%$, $p = 0.79$) (Figure 4).

Due to the limited number of studies included in the meta-analysis ($n = 3$), formal sensitivity analyses – such as subgroup analyses or meta-regression – could not be conducted. According to methodological guidelines, including *The Cochrane Handbook for Systematic Reviews of Interventions*, meta-regression requires a minimum of 10 studies to yield reliable and interpretable results, as analyses based on smaller numbers are prone to false-positive findings and low statistical power [36]. In this review, all included studies provided complete data for SMDs and standard deviations, and no imputations or statistical assumptions were required. Given the uniformity in data reporting and the observed low heterogeneity ($I^2 = 0\%$), the meta-analysis results are considered stable within the limitations of the dataset. To evaluate the potential for publication bias, a funnel plot was constructed, and both Egger's test and Begg's test were performed. Egger's test yielded an intercept of −1.37 (95% CI: −8.58 to 5.84; $p = 0.49$), while Begg's test showed a Kendall's tau of −0.33 ($p = 0.49$), indicating no significant evidence of publication bias. Although visual inspection of the funnel plot showed mild asymmetry, the small number of included studies ($n = 3$) limits the power to detect true asymmetry. These results should therefore be interpreted with caution (Figure 5).

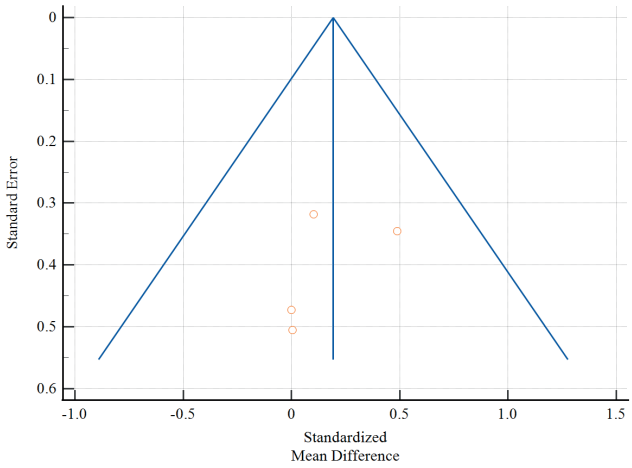

Figure 5. Funnel plot for assessment of publication bias in studies evaluating the effect of kinesiology taping on lower limb muscle activation

Discussion

The current review examined ten relevant studies that compared the impact of KT to either no taping or a control group, focusing on muscle activation assessed through sEMG in athletes and healthy adults. Our analysis suggests that extending facilitatory training for an extended period, potentially up to 48 hours, may positively influence muscle activation in both healthy adults and athletes. Nevertheless, it is essential to note that IKT training could result in a decrease in muscle activation.

The review revealed that FKT, applied from the origin of the muscle to insertion, generally led to increased muscle activity when used for longer durations, supporting its role in muscle facilitation or activation. In contrast, IKT, applied from insertion to origin, showed inconsistent effects – sometimes reducing activation as intended, but occasionally increasing it unexpectedly. This distinction is important, as clinical application of KT should consider not only the tape direction but also its duration and target muscle.

Facilitatory KT vs. no taping/control on muscle activation

In the present review, five included studies have compared the effect of FKT with the control group. One study has shown a significant improvement in the activity of the gluteus medius muscle after 48 hours of FKT application [32] and another study has found an increase in the percentage of maximum voluntary isometric contraction (MVIC) of the gastrocnemius muscle [34]. Previous evidence suggested that cutaneous stimulation of the tape may increase the sensitivity of type 2 mechanoreceptors and improve motor unit recruitment, which may be responsible for increased activation [11, 37]. Furthermore, concentric traction is exerted by FKT on the fascia, which may increase muscle contraction by decreasing the distance between the muscle origin and insertion [38].

On the contrary, the rest of the three studies did not report any significant changes in muscle activity following FKT application [19, 27, 30]. The reason could be the shorter duration of tape application because all three studies either saw the effect immediately or after 24 hours. This can be justified by the findings of a previous study that demonstrated the longer the duration of KT application, the better the muscle strength [39]. From previous evidence it is proven that there is a linear relation between muscle strength and muscle activity assessed using EMG [40].

Inhibitory KT vs. no taping/control on muscle activation

The present review has included four studies that have used the IKT technique on the gastrocnemius muscle and compared it to the control group [17, 28, 33]. Only two included studies have reported increased muscle activation following IKT [17, 33]. This increase in muscle activity could be explained by central nervous system neuromodulation caused by cutaneous mechanoreceptor activation [41].

One study has reported no change in the amplitude of sEMG but has noted decreased duration of lateral gastrocnemius activity [28]. Another study has reported decreased percentage of MVIC [34]. The decreased duration of lateral gastrocnemius activity may be due to an inhibitory modulation of the skin stretch receptors. The direction of pull and muscle contraction is occurring in opposing directions in IKT, which can result in stretching the Golgi tendon organs preventing muscular contraction and consequently leading to decreased muscle activity [9, 11].

Effects of facilitatory KT vs. inhibitory KT on muscle activation

Three studies provide insights into the effects of FKT and IKT on muscle activation. Raza et al. [34] demonstrated that FKT significantly increased gastrocnemius muscle activity and countermovement jump height, while IKT reduced vastus lateralis activity, potentially due to the eccentric pulling force weakening muscle contractions. This study also noted that playing positions (attacker or defender) did not influence these outcomes. Similarly, Sinaei et al. [29] reported that FKT enhanced vastus medialis oblique (VMO) activity, whereas IKT decreased vastus lateralis (VL) activity, resulting in an improved VMO : VL activity ratio in athletes with patellofemoral pain, alongside reductions in pain and improved dynamic balance [29]. However, Serrão et al. [31] found no significant changes in quadriceps or hamstring muscle activity during barbell back squats with either FKT or IKT, suggesting limited neuromuscular effects during high-intensity dynamic exercises. These findings highlight the variability of the effects of KT, with therapeutic benefits in controlled settings [29, 34] but inconsistent results during high-load functional tasks [31].

Mechanisms of KT in muscle activation

KT is thought to influence muscle activation through a combination of neurological, mechanical, and circulatory mechanisms. From a neurophysiological perspective, KT stimulates cutaneous mechanoreceptors, which may

enhance afferent sensory feedback to the central nervous system. This input is believed to modulate spinal reflex excitability and influence alpha motor neuron activity, thereby facilitating motor unit recruitment in the taped muscle [10, 38]. The stimulation may also improve proprioception, which is particularly relevant in dynamic tasks requiring joint stability and neuromuscular control [42, 43]. Mechanically, the elastic nature of KT allows it to be stretched up to 140% of its resting length, mimicking the compliance of human skin. Once applied, KT exhibits a recoiling effect, which microscopically lifts the epidermis and dermis away from the underlying fascia [10]. This "skin-lifting" action is thought to decompress subcutaneous nociceptors and lymphatic vessels, thereby improving blood and lymphatic circulation, reducing edema, and decreasing localized pain and muscle inhibition [44, 45]. By reducing inhibitory inputs caused by pain or swelling, KT may enable more effective muscle contraction and support neuromuscular reeducation during movement [46].

However, while these mechanisms are theoretically plausible and supported by some studies, empirical evidence remains inconsistent. The effects of KT on muscle activation may vary depending on factors such as tape tension, application technique (facilitatory vs. inhibitory direction), duration of application, and individual anatomical or functional characteristics [37, 47]. In our review, some studies demonstrated increased EMG activity post-KT, while others showed no significant effect, reinforcing the notion that the effects of KT are context-specific and warrant further exploration in standardized, high-quality trials.

Limitations

The present review has certain limitations. First, blinding of the assessor and participants was either absent or unclear in most of the studies. Second, the population examined in the present review was heterogeneous, including athletes from various sports as well as healthy adults. This heterogeneity can introduce variability in terms of physical demands, training protocols, neuromuscular baselines, and injury profiles across different sports disciplines. Third, the majority of studies investigated only the short-term effects of KT, often limited to a single session or 24-72 hours of application. This brief duration does not adequately reflect the long-term effects or clinical relevance of KT interventions in ongoing training or rehabilitation programs. Fourth, one study utilized a crossover trial design, and the potential carryover effect may have influenced the outcome measures, potentially confounding the within-subject comparison.

Moreover, significant heterogeneity was observed across studies in terms of taping protocols (e.g., tape brand, tension level, direction of application), target muscle groups (e.g., quadriceps, gastrocnemius, gluteus medius), and outcome measures (e.g., % MVIC, RMS, activation onset/offset timing). This diversity limits the ability to generalize findings across populations and clinical settings. Variability in taping technique and anatomical focus may influence neuromuscular response and reduce comparability between studies.

Additionally, the review faced several real-time limitations during its execution. Language restrictions excluded non-English articles, and access to regional or grey literature databases was limited, which may have led to omission of relevant studies. Due to time and resource constraints, we did not contact study authors for missing data, which may have contributed to the exclusion of otherwise eligible trials from the meta-analysis. Furthermore, variability in KT application methods (e.g., tension, tape brand, taping direction) and differences in muscle outcome measures (e.g., % MVIC vs. EMG amplitude) could not be fully controlled due to the small number of studies included. Finally, only three studies met the inclusion criteria for quantitative synthesis, which limited the statistical power and feasibility of advanced analyses such as meta-regression, subgroup comparisons, or funnel plot interpretation with high confidence.

The findings of this review provide actionable insights for clinicians, researchers, and athletes. For clinicians and physiotherapists, KT may be considered as a non-invasive and easily applicable adjunctive strategy for muscle facilitation, particularly when applied with a facilitatory technique over extended durations. However, caution is warranted in expecting consistent results, especially when using inhibitory taping approaches. For researchers, this review identifies the need for high-quality, standardized protocols that address inconsistencies in tape application, muscle group selection, and outcome measurement timing. For athletes and healthy individuals, these results suggest that while KT may offer short-term perceptual or neuromuscular benefits in some contexts, its effects on actual muscle activation are not yet consistently supported by high-certainty evidence.

Strength

Despite the presence of the above-mentioned limitations, our review possesses several potential strengths that contribute to its overall value. Firstly, the current review is a comprehensive piece of a single

document focusing on the effect of KT on the muscle activation of the lower limb in athletes and healthy adults. By summarizing multiple studies into one review, it provides a single abridgment for researchers, practitioners, and physiotherapists interested in this specific topic. Furthermore, the review employed a standard protocol for assessing the risk of bias. The use of a standardized assessment protocol helps to minimize bias in this review. Additionally, all the trials included in the review were randomized. RCTs are considered to be the gold standard in clinical research as they help minimize confounding variables and provide a stronger basis for causal inference. By including only randomized trials, the review demonstrates a higher level of scientific rigor and credibility.

Clinical implication and future perspectives

The findings of this review suggest that KT may have variable effects on muscle activation, with outcomes influenced by factors such as taping technique, population type, and intervention duration. Clinically, KT may be considered a supplementary, non-invasive intervention in sports and rehabilitation contexts. However, the current evidence base is not strong enough to support widespread or standardized clinical use for enhancing muscle activation.

For practitioners and athletic trainers, this suggests that FKT may be cautiously applied as a short-term adjunct to improve neuromuscular activation, especially when used for extended durations (48-72 hours). This may be particularly useful in early rehabilitation, mild neuromuscular deficits, or muscle retraining scenarios. In contrast, due to the small, statistically nonsignificant effects observed in our meta-analysis and the inconsistency across individual studies, IKT should not be relied upon to reduce muscle activation with clinical confidence. Trainers should also be aware that KT does not replace structured strength or neuromuscular reeducation programs and may be best suited for low-load, controlled movements rather than high-intensity athletic tasks. Overall, KT should be regarded as a supportive, context-specific tool rather than a primary therapeutic strategy, and its use should be guided by individual patient response, therapeutic goals, and functional demands.

Future research should prioritize conducting high-quality RCTs with low risk of performance and detection bias. Studies involving homogeneous populations – such as athletes from the same sport, age group, or training level – are essential to reduce intersubject variability and improve generalizability. Longitudinal trials are needed to assess the sustained effects of KT over time, as most current research only evaluates immediate or short-term outcomes.

Moreover, the physiological mechanisms underlying the effects of KT remain poorly understood. Future studies should integrate neurophysiological and biomechanical assessments, including EMG signal characteristics, proprioceptive feedback loops, and sensorimotor integration, to clarify the pathways by which KT may influence neuromuscular function. It is also recommended that future research investigate the dose-response relationship of KT – evaluating the impact of variables such as application duration, tension levels, and frequency of reapplication.

Additionally, full and transparent reporting of statistical data (means, standard deviations, confidence intervals) is critical to support future meta-analyses and facilitate evidence synthesis. As the evidence base grows, more complex methodologies such as network meta-analysis and meta-regression can be employed to explore effect modifiers and generate clinically useful recommendations.

Conclusions

This systematic review and meta-analysis evaluated the effects of KT on lower limb muscle activation in healthy adults and athletes. Among the ten included studies, results were mixed, with some reporting increased muscle activation and others showing no significant effect. Meta-analysis of three studies focusing on IKT revealed a small, statistically nonsignificant effect. Given the low heterogeneity and methodological limitations, current evidence does not support strong conclusions regarding the efficacy of KT for enhancing muscle activation. Further high-quality, standardized trials are needed to clarify its role in sports performance and rehabilitation.

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Conflict of Interest

The authors declare no conflict of interest.

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