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Literature Review

Sticking to the facts: A systematic review of the effects of therapeutic tape in lateral epicondylalgia

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ABSTRACT

Objective: To systematically identify, appraise, and examine evidence regarding the effects of therapeutic tape on pain and function in individuals with lateral epicondylalgia (LE).
Methods: Five electronic databases were systematically searched up to March 2018. Full-text, peer-reviewed, English-language studies were included if they had an LE population, a standalone tape condition, and an outcome related to pain or function.
Results: Eight out of 2022 screened studies were included. Three studies demonstrated immediate (i.e. within 1 h) improvements in pain and pain-free grip strength following diamond deloading rigid tape. One study reported immediate improvements in proprioception following transverse rigid tape. The immediate effects of longitudinal kinesiotape were inconsistent. One study reported improvements in pain and pain-free grip strength, while another study reported no effect on pain, strength, or muscle activity. Two studies examined short-term (i.e. within six weeks) kinesiotape application. One study reported two weeks of longitudinal kinesiotape improved pain and maximum grip strength. The other study reported one week of diamond kinesiotape improved patient-reported pain and function, but not maximum grip strength.
Conclusions: In individuals with LE, diamond deloading rigid tape may immediately improve pain and strength. There is conflicting evidence regarding kinesiotape effects in both immediate and short-term timeframes.

1. Introduction

Lateral epicondylalgia (LE), or tennis elbow, is a musculoskeletal condition characterised as pain over the lateral epicondyle, commonly provoked by gripping (Saroja, Antony Leo Aseer, & Venkata Sai, 2014). It is estimated LE affects up to 3% of the general population (Shiri et al., 2006) and up to 20% of factory workers (Leclerc et al., 2001; Roquelaure et al., 2006). Men and women are affected equally by LE (Walker-Bone et al., 2004), with individuals aged 40–54 years most susceptible (Shiri et al., 2006; Titchener et al., 2012). Risk factors include repetitive or forceful movements of the forearm or wrist (Haahr & Andersen, 2003), and forceful gripping in ≥45° forearm pronation (Fan et al., 2014). Compared to asymptomatic controls, individuals with LE exhibit sensory system changes (e.g. pain) (Coombes, Bisset, & Vicenzino, 2012; Fernández-Carnero et al., 2009; Jespersen et al., 2013; Ruiz-Ruiz et al., 2011), and neuromuscular impairments (e.g. reduced grip strength) (Bisset et al., 2006a; Heales et al., 2016a, 2016b). These impairments have substantial impacts on participation in work, sport, and activities of daily living (ADLs). (Walker-Bone, 2012).

Treatment for LE typically aims to reduce pain, alter musculotendinous load, and improve neuromuscular strength and control (Coombes, Bisset, & Vicenzino, 2015). One commonly used treatment option is therapeutic tape (Bateman et al., 2018). Therapeutic tape has been proposed to alleviate pain (Vicenzino, 2003; Vicenzino et al., 2003), improve muscle load and function (Vicenzino et al., 2003), and restore efficient movement patterns (Vicenzino, 2003). At present, there are two main types of tape used to treat LE. The first, rigid strapping tape, is purported to deload the

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common extensor tendon and wrist extensor muscles (Lee et al., 2011; Vicenzino, 2003; Vicenzino et al., 2003). The other, kinesiotape, is proposed to reduce pain by altering descending pain inhibitory systems via tactile stimulation of skin (Kase, Wallis, & Tsuyoshi, 2003). Either tape can be applied using numerous techniques and no consensus exists regarding optimal tape type or application technique (Bisset & Vicenzino, 2015).

The only systematic review of therapeutic tape in LE examined the effects of kinesiotape, used alone or as an adjunct to other treatment modalities (e.g. therapeutic exercise) (Behbahani et al., 2014). Although highlighting positive effects of kinesiotape on pain (Behbahani et al., 2014), there were several limitations of this review. First, quality appraisal of included studies was not undertaken which may introduce bias. Second, inclusion of mixed modalities (e.g. tape plus therapeutic exercise) could falsely inflate the benefit of tape, as the relative contribution of each intervention is difficult to quantify. Finally, a focus on kinesiotape does not fully describe therapeutic tape use in clinical practice; thus, limiting translational potential. Therefore, the aim of the present systematic review is to identify, appraise, and examine studies investigating the effects of therapeutic tape on pain and function in individuals with LE.

2. Methods

2.1. Protocol and registration

This systematic review was registered with PROSPERO (registration number: CRD42018095484) and written according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009).

2.2. Eligibility criteria

Studies were eligible for inclusion if they had: (1) a sample population with LE (either unilateral or bilateral) of any duration, diagnosed by a clinician; (2) a tape-only 'intervention' (e.g. rigid tape, kinesiotape) with no other concurrent treatment (e.g. exercise, corticosteroid injection); (3) an untaped comparator condition provided either as a baseline measurement (i.e. before application), a separate experimental condition, or an unaffected limb; (4) an outcome related to pain (e.g. visual analogue scale, pressure pain thresholds [PPT]), or function (e.g. grip strength); and (5) a full-text, peer-reviewed, English-language manuscript. Single subject case studies, conference abstracts, retrospective studies, and reviews were excluded.

2.3. Information sources

A comprehensive electronic search of CINAHL, PubMed, ScienceDirect, Scopus, and SportDiscus was undertaken to identify all English-language studies up to March 2018. The search strategy combined anatomical location terms (e.g. 'lateral elbow', 'lateral epicondyle', 'common extensor', AND 'tendon*', 'tendin*', 'enthes*'), pathological terms (e.g. 'tennis elbow', 'lateral epicondylalgia', 'lateral elbow pain'), and intervention terms (e.g. 'tape', 'taping', 'strap*', 'kinesio*', 'ktape'). To identify additional potentially relevant studies missed by the electronic search, a single reviewer (CG) searched the reference lists of all full-text studies. The grey literature (e.g. book chapters, theses) was searched using simplified terms in an online search engine (www.google.com) (Mahood, Van Eerd, & Irvin, 2014). The detailed search strategy is provided in Online Supplementary File A.

2.4. Study selection

Search results were imported into Endnote X8.1 for Windows (Clarivate Analytics, Philadelphia, PA, USA) and duplicates were removed. Titles and abstracts were then screened by two independent reviewers (CG, SW). Full-texts of potentially relevant studies were obtained and assessed by two independent reviewers (CG, SW) using predetermined criteria to assess eligibility for inclusion. Disagreements between reviewers were resolved by discussion with a third independent reviewer (CK).

2.5. Data collection

Data were collected by one reviewer (CG) with queries discussed by additional reviewers (CK, LH, RS). Data describing the participant characteristics (i.e. age, sex, and duration of symptoms) and study methods (i.e. experimental design, inclusion/exclusion criteria, outcome measures, statistical analyses, and completion rates) were extracted. For each outcome measure, the mean, standard deviation (SD), and effect sizes (where available) were obtained. Where necessary, authors were contacted for additional data (Au et al., 2017; Dilek et al., 2016; Goel, Balthilaya, & Reddy, 2015; Shamsoddini, Hollisaz, & Hafezi, 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003), clarification of intervention (Shakeri et al., 2017) and outcome measurement methods (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013). Two authors (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) returned *p*-values for within-group change and clarification regarding outcome measurement. One author (Vicenzino et al., 2003) replied but could not access data due to the length of time elapsed. Where data were graphical and no author response was received (Dilek et al., 2016; Goel et al., 2015), means were approximated from figures using WebPlotDigitzer (Edition 4.0. Austin, TX, USA) (Hoogeboom et al., 2012).

2.6. Risk of bias for individual studies

Two independent reviewers (CG, SW) assessed study quality and risk of bias using the Epidemiological Appraisal Instrument (EAI), a reliable, valid, and comprehensive appraisal tool of 43 items grouped into five scales (i.e. reporting, subject selection, measurement quality, data analysis, and generalisation of results) (Genaidy et al., 2007). The EAI is modifiable according to study design (Genaidy et al., 2007) and has been used previously (Darlow et al., 2012; Heales et al., 2014). Seven items were deemed irrelevant for the present review (e.g. exposure variables, observation period) and were removed *a priori*, leaving 36 items. Each item was scored using the EAI scale: 'yes' = 1, 'partial' = 0.5, 'no' = 0, 'unable to determine' = 0 (Genaidy et al., 2007). Items scored as 'not applicable' were removed and excluded from the overall score. Study quality scores were recorded as the mean of the total score for all included items (Genaidy et al., 2007). Thus, scores ranged from zero to one, with a higher score indicating higher study quality and lower risk of bias.

2.7. Synthesis of results

Agreement between the two reviewers for the quality assessment was calculated using Kappa (κ) statistic with 95% CI analysed using SPSS, Version 25 (IBM Corp., Armonk, NY, USA). Inter-rater reliability was categorised as poor (<0.00), slight (0.00–0.2), fair (0.21–0.4), moderate (0.41–0.6), substantial (0.61–0.8), or almost perfect (0.81–1.0) (Landis & Koch, 1977). Due to heterogeneity between included studies, meta-analysis was not possible; therefore, a narrative synthesis was conducted. The repeated-measures design of most studies (Au et al., 2017; Dilek et al., 2016; Goel et al., 2015; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003), and the lack of reported data (i.e. *t*-statistics or SD of the change scores), precluded calculation of appropriate paired data effect sizes (Dankel & Loenneke, 2018). To facilitate synthesis, percentage change between the comparator condition mean and post-application mean was calculated using: $\% \ change = ((post\text{-}application - comparator)/baseline) * 100$. Percentage changes calculated with this formula differ from the results of one study (Goel et al., 2015).

2.8. Risk of bias across studies

Funnel plot assessment of publication bias was precluded by a lack of reported effect sizes or estimates of study precision (Lakens, 2013) in a majority of studies (Dilek et al., 2016; Goel et al., 2015; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013). Exclusion of studies published in languages other than English is unlikely to have a significant impact on the findings of the present review (Jüni et al., 2002).

3. Results

3.1. Study selection

Database searches identified 920 studies, with 42 potentially relevant studies included for full-text review. Screening of 1102 titles from the reference lists of potentially relevant studies (total studies screened: n=2022) revealed 12 additional potentially relevant studies. The grey literature search identified no additional studies; thus, 54 full-text studies were reviewed. Of these, eight met the inclusion criteria and were included in the present review (Fig. 1).

3.2. Study characteristics

Detailed study characteristics are presented in Table 1. In studies examining the immediate effects of tape, outcomes were measured at 0 min, or at 0 and 30 min, following each condition. In short-term treatment studies, tape was applied multiple times over one or two weeks, with or without follow-up outcome measures. Six studies investigated the immediate effects of five tape techniques: (1) diamond deloading rigid tape (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003), (2) transverse circumferential rigid tape (Lee et al., 2011), (3) inhibitory kinesiotape (Au et al., 2017), (4) facilitatory kinesiotape (Au et al., 2017), and (5) inhibitory kinesiotape with a fascial correction (Goel et al., 2015). One study included a placebo diamond rigid tape technique (Vicenzino et al., 2003) and one study included a placebo facilitatory kinesiotape technique (Au et al., 2017). Two studies investigated the short-term treatment effects of two kinesiotape techniques: (1) facilitatory kinesiotape with longitudinal split in the centre of the tape, applied four times over two weeks, with a six-week follow-up (Dilek et al., 2016), and (2) diamond kinesiotape, applied three times in one week, with no additional follow-up (Shakeri et al., 2017). One study included placebo diamond

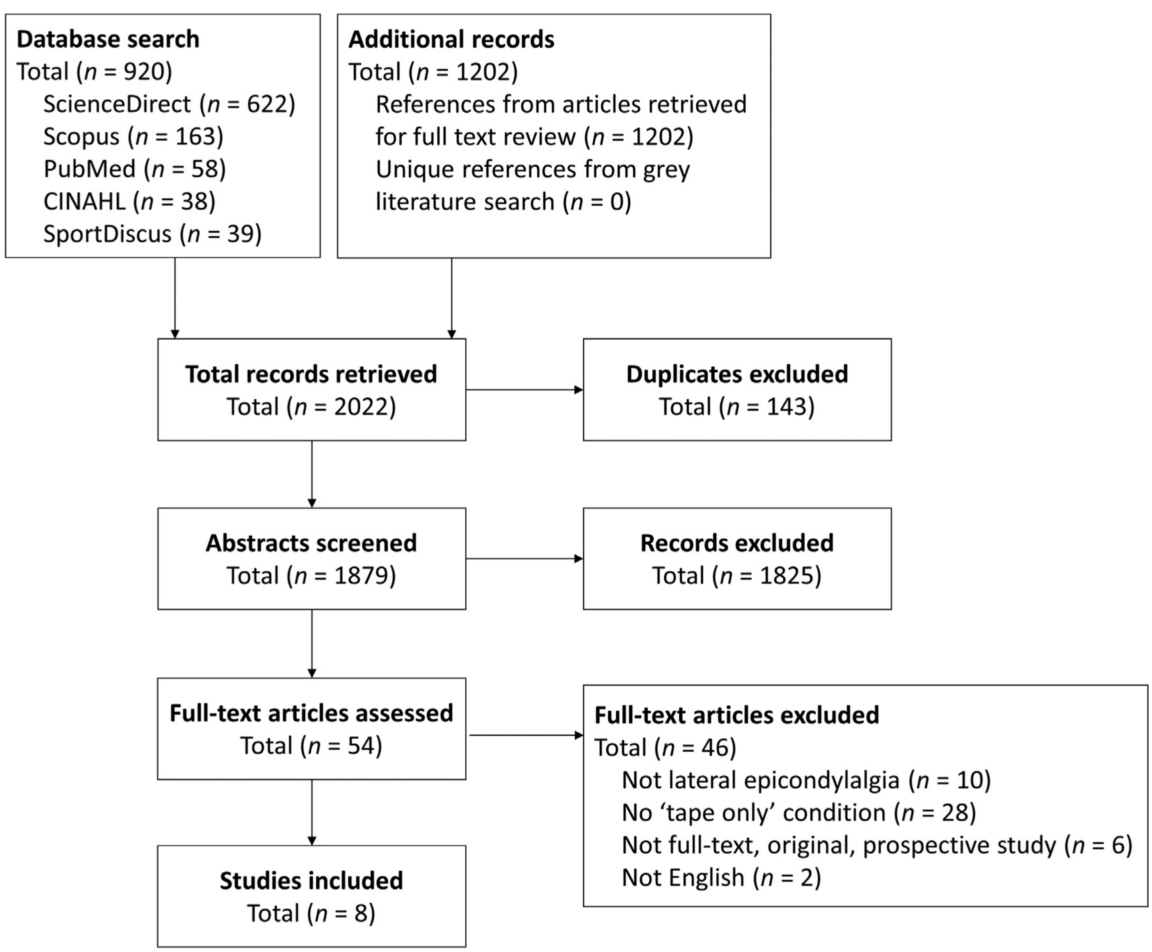

Fig. 1. Selection process for inclusion in the present review.

Table 1
Characteristics of studies investigating the effects of therapeutic tape.

Timeframe	Study Design	Author	Study location	Participants (N, sex, DOS)	Conditions/interventions	Measurement time points	EAI score
Immediate effects of tape	Randomised crossover trial	Vicenzino et al. (2003)	Brisbane, Australia	N = 16 (LE), 4F, 13.0 ± 9.9 months	Diamond deloading rigid tape Placebo rigid tape (no tension) Control (no tape)	Baseline 0 minutes after tape/control condition application 30 minutes after tape/control condition application	0.57
		Goel et al. (2015)	Manipal, India	N = 16 (LE), 7F, 14.8 ± 11.7 months	Diamond deloading rigid tape Inhibitory kinesiotape (with fascial correction)	Baseline 0 minutes after tape application 30 minutes after tape application	0.46
		Au et al. (2017)	Hong Kong & Macau, China	N = 30 (LE), 25F, *NR*	Inhibitory kinesiotape Facilitatory kinesiotape Placebo kinesiotape (no tension) Control (no tape)	0 minutes after tape/control condition application	0.72
	Within-subject trial	Shamsoddini et al. (2010)	Tehran, Iran	N = 15 (LE), 5F, 5.1 ± 1.1 weeks	Diamond deloading rigid tape (applied to affected and unaffected arm)	Baseline 0 minutes after tape application	0.46
		Shamsoddini & Holllisaz (2013)	Tehran, Iran	N = 30 (LE), 14F, 6.4 ± 1.3 weeks	Diamond deloading rigid tape (participant-applied to affected and unaffected arm)	Baseline 0 minutes after tape application	0.39
	Case-controlled trial	Lee et al. (2011)	Seoul, Korea	N = 15 (LE group), *NR*, *NR* N = 15 (healthy group), *NR*, N/A	Transverse circumferential rigid tape	Baseline 0 minutes after tape application	0.44
Short-term effects of tape	Within-subject trial	Dilek et al. (2016)	İzmir, Turkey	N = 31 (LE), 23F, 5.6 ± 5.1 months	Four applications of facilitatory kinesiotape over two weeks	Baseline Two weeks after baseline (following two weeks of treatment) Six weeks after baseline (following four weeks of no treatment)	0.41
	Randomised controlled trial	Shakeri et al. (2017)	Tehran, Iran	N = 30 (LE), 30F, *NR*	Three applications of diamond kinesiotape over one week Three applications of placebo kinesiotape (no tension) over one week	Baseline One week after baseline (following one week of treatment)	0.60

Study quality rated from 0 to 1, as the mean of total score of included Epidemiological Appraisal Instrument (EAI) items. Abbreviations: DOS – duration of symptoms, LE – lateral epicondylalgia, F – female, N – number of participants, *NR* – not reported.

kinesiotape (Shakeri et al., 2017), and no studies included a wait-and-see condition. Images and descriptions of all tape techniques are available in Online Supplementary Material B. Nine outcomes measuring pain, including patient-rated pain intensity and mechanical pain sensitivity, and eight outcomes measuring function, including strength, sensorimotor function, and patient-rated questionnaires are described in Table 2.

3.3. Risk of bias within studies

Agreement between the two independent reviewers (CG, SW) was almost perfect ($\kappa = 0.95$ (95% CI: 0.92, 0.98), $p < 0.001$), with 276 agreements out of 288 decisions. The EAI scores of included studies ranged from 0.39 to 0.72 (see Table 1 for EAI scores and Online Supplementary Material C for detailed quality and risk appraisal). Study aims, interventions, outcomes, design, statistical techniques, and main findings were reported in all studies. Two studies (Au et al., 2017; Goel et al., 2015) reported sample size calculations. One study (Dilek et al., 2016) reported no adverse effects and seven studies (Au et al., 2017; Goel et al., 2015; Lee et al., 2011; Shakeri et al., 2017; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003) did not discuss adverse effects. Risk of selection bias was low in two studies (Au et al., 2017; Shakeri et al., 2017) due to randomisation procedures, unclear in two studies (Goel et al., 2015; Vicenzino et al., 2003), and not applicable due to study design in four studies (Dilek et al., 2016; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013). Risk of performance bias was low in two studies (Au et al., 2017; Vicenzino et al., 2003) due to participant blinding and detection bias risk was low in one study (Shakeri et al., 2017) due to assessor blinding. All other studies (Dilek et al., 2016; Goel et al., 2015; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) had an unclear or high risk of performance and detection bias due to lack of blinding. A risk of attrition bias was high in four studies (Dilek et al., 2016; Goel et al., 2015; Shakeri et al., 2017; Vicenzino et al., 2003) due to incomplete reporting of outcome data for subjects and not applicable due to single session design in four studies (Au et al., 2017; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013). A high risk of reporting bias was present in seven studies (Au et al., 2017; Dilek et al., 2016; Goel et al., 2015; Lee et al., 2011; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003) due to insufficient data availability for meta-analysis (e.g. standard error of the measurement, *t*-statistics). There is a high risk of bias specific to the insufficient washout period in one study (Au et al., 2017).

3.4. Synthesis of results

3.4.1. Immediate effect of therapeutic tape on pain

Five studies (Vicenzino et al., 2003; Goel et al., 2015; Au et al., 2017; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) examined the immediate effects of therapeutic tape on pain (Fig. 2). Compared to baseline, two studies (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) revealed a 46% and 52% decrease in

Table 2
Description of outcome measures.

Outcome	Specific measure	Authors	Description
Pain intensity	At rest	Goel et al. (2015), Shamsoddini et al. (2010); Shamsoddini & Holllisaz; (2013), Dilek et al. (2016)	Rated on a VAS (0 = no pain and 10 = worst pain imaginable)
	At night	Dilek et al. (2016)	Rated on a VAS (0 = no pain and 10 = worst pain imaginable)
	During ADLs	Dilek et al. (2016), Shakeri et al. (2017)	Rated on a VAS (0 = no pain and 10 = worst pain imaginable)
	During palpation of the lateral epicondyle	Dilek et al. (2016)	Rated on a VAS (0 = no pain and 10 = worst pain imaginable)
	During palpation of forearm extensor MTrP	Shakeri et al. (2017)	Rated on a VAS (0 = no pain and 10 = worst pain imaginable)
	During maximum grip	Au et al. (2017)	Rated using a VNRS (0 = no pain and 10 = worst possible pain)
	Nirschl pain score	Dilek et al. (2016)	Rated on a seven-point scale indicating severity of LE, higher score represents greater pain
Mechanical pain sensitivity	PPT at the lateral epicondyle	Vicenzino et al. (2003), Goel et al. (2015)	Measured by pressure algometry over the lateral epicondyle
	PPT over a forearm extensor MTrP	Shakeri et al. (2017)	Measured by pressure algometry over a MTrP in forearm extensor muscles
Strength	Maximum grip strength	Au et al. (2017), Shamsoddini et al. (2010), Shamsoddini & Holllisaz (2013), Dilek et al. (2016)	Maximum voluntary grip force measured by a grip force dynamometer
	Pain-free grip strength	Vicenzino et al. (2003), Goel et al. (2015), Au et al. (2017)	Force measured by a grip force dynamometer at the onset of pain
	Wrist extension strength	Shamsoddini et al. (2010), Shamsoddini & Holllisaz (2013)	Maximum voluntary wrist extension force measured by a hand-held dynamometer
Sensorimotor outcomes	Wrist extension muscle activity	Au et al. (2017)	Measured during pain-free and maximum grip strength efforts by surface EMG
	Wrist extension force reproduction error	Lee et al. (2011)	Measured as the difference between the participant's attempt to reproduce 20% maximum voluntary wrist extension force without feedback and the true force
	Wrist extension joint position reproduction error	Lee et al. (2011)	The difference between the participant's attempt to reproduce a 20 deg, 25 deg, and 30 deg wrist extension angle without feedback and the true angle
Participant-rated function	DASH questionnaire	Shakeri et al. (2017)	A 30-item questionnaire measuring upper limb function, higher score represents greater pain and disability
	PRTEE	Dilek et al. (2016)	A 15-item questionnaire specific pain and disability in LE, higher score represents greater pain and disability

Abbreviations: ADLs – activities of daily living, DASH – Disability of the Arm, Shoulder and Hand, EMG – electromyography, LE – lateral epicondylalgia; MTrP – myofascial trigger point, PPT – pressure pain threshold, PRTEE – patient-rated tennis elbow evaluation, VAS – visual analogue scale, VNRS – verbal numerical rating scale.

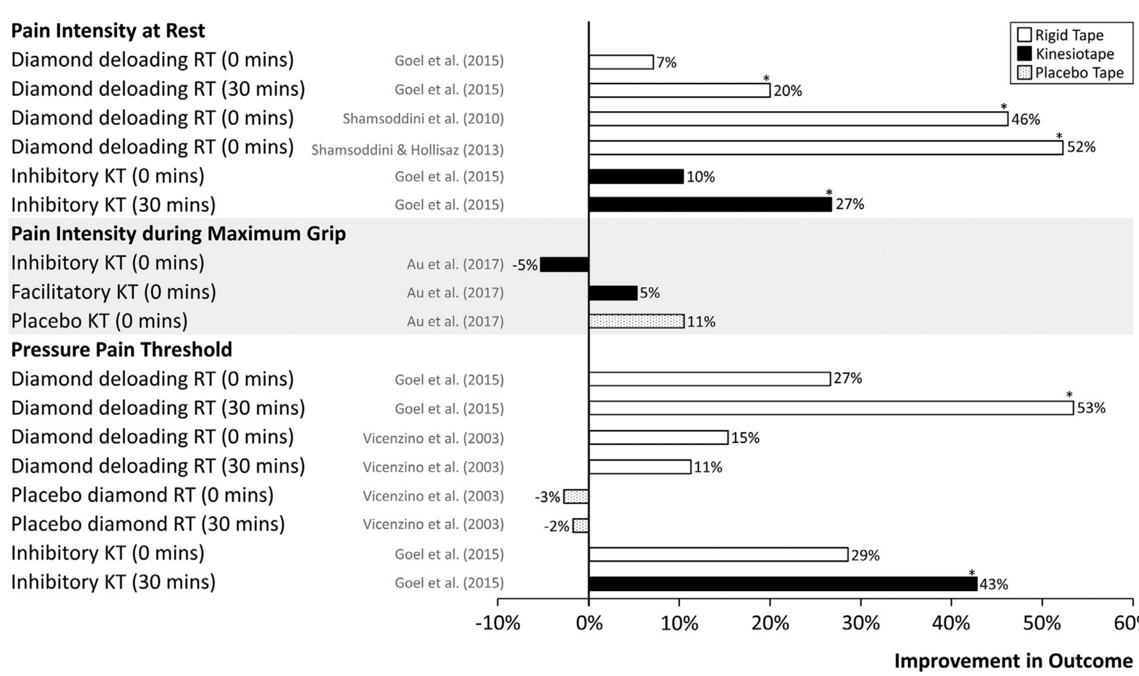

Fig. 2. Immediate effects of therapeutic tape on pain-related outcome measures. Improvement in pain intensity represents decreased VAS or numerical rating scale values; improvement in PPT represents increased pressure prior to onset of pain; values adjacent to bar indicate actual percentage change; RT – rigid tape, KT – kinesiotape; *denotes significant change from baseline/no tape condition.

resting pain intensity at 0 min following application of diamond deloading tape ($p < 0.05$). Goel et al. (2015) reported no significant decrease in resting pain intensity at 0 min following application of diamond deloading tape or inhibitory kinesiotape; however, at 30 min resting pain intensity had significantly decreased by 20% and 27%, respectively (both $p < 0.05$). In contrast, no significant difference in pain intensity during maximum grip strength was identified immediately following inhibitory, facilitatory, or placebo kinesiotape, compared to a control (no tape) condition (Au et al., 2017).

Two studies (Vicenzino et al., 2003; Goel et al., 2015) measured PPTs at the symptomatic lateral epicondyle (Fig. 2). Goel et al. (2015) did not report a significant difference in PPTs at 0 min following application of diamond deloading tape or inhibitory kinesiotape; however, at 30 min PPTs had significantly increased by 53% and 43%, respectively (both $p < 0.05$). In contrast, Vicenzino et al. (2003) did not identify significant differences in PPTs at 0 and 30 min after application of diamond deloading tape (0 min: 15%; 30 min: 11%, Bonferroni adjusted $p \geq 0.008$). There was also no significant difference in PPTs following application of placebo

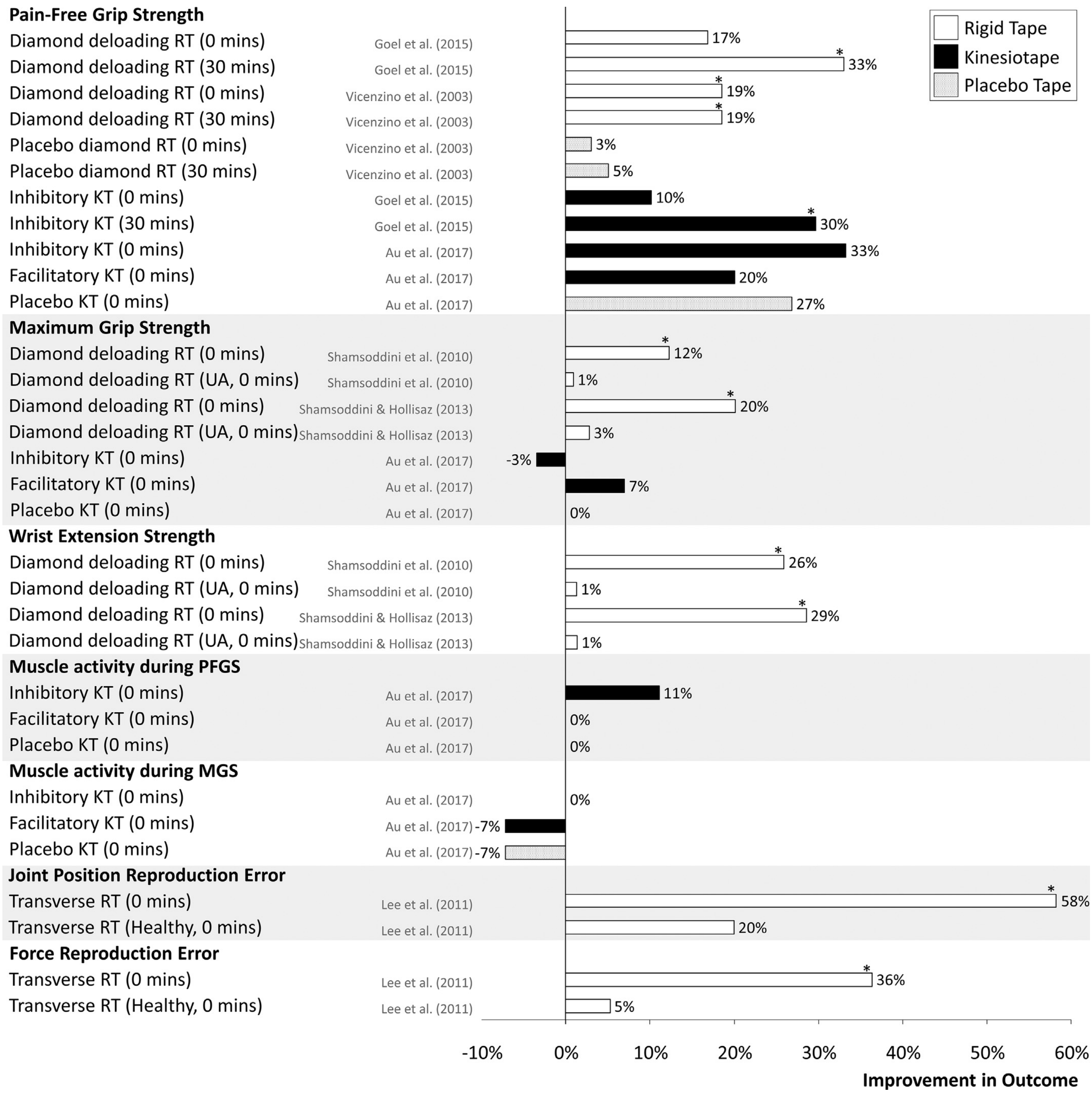

Fig. 3. Immediate effects of therapeutic tape on function-related outcome measures. Improvement in strength represents increased force; improvement in muscle activity represents increased electromyographic activity of wrist extensor muscles; improvement in joint position or force reproduction error represents less error in deg or kg; values adjacent to bar indicate actual percentage change; KT – kinesiotape, MGS – maximum grip strength, PFGS – pain-free grip strength, RT – rigid tape, UA - Unaffected; *denotes significant change from baseline/no tape condition.

diamond tape or control (no tape) conditions (Vicenzino et al., 2003).

3.4.2. Immediate effect of therapeutic tape on function

Six studies (Vicenzino et al., 2003; Lee et al., 2011; Goel et al., 2015; Au et al., 2017; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) examined the immediate effects of therapeutic tape on function (Fig. 3). Pain-free grip strength was investigated in three studies. Compared to baseline, Vicenzino et al. (2003) reported a 19% increase in pain-free grip strength from baseline at both 0 and 30 min following application of diamond deloading tape (Bonferroni adjusted $p < 0.008$). No significant change was observed in pain-free grip strength following placebo rigid tape and control (no tape) conditions (Vicenzino et al., 2003). Goel et al. (2015) did not identify a significant change in pain-free grip strength at 0 min following application of diamond deloading tape or inhibitory kinesiotape; however, at 30 min pain-free grip strength had significantly increased by 33% and 30%, respectively (both $p < 0.05$). In contrast, no significant difference in pain-free grip strength or forearm extensor muscle activity during pain-free grip strength was identified immediately following inhibitory, facilitatory, or placebo kinesiotape, compared to a control (no tape) condition (Au et al., 2017).

Two studies (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) reported a 12% and 20% increase in maximum grip strength immediately following application of diamond deloading tape ($p < 0.05$). In both studies (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013), maximum grip strength change scores in the affected arm were greater than change scores in the unaffected arm ($p < 0.05$). In contrast, no significant difference in maximum grip strength or forearm extensor muscle activity during maximum grip strength was identified immediately following inhibitory, facilitatory, or placebo kinesiotape, compared to a control (no tape) condition (Au et al., 2017).

Two studies (Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) reported a 26% and 27% increase in wrist extension strength in the affected arm following application of diamond deloading tape ($p < 0.05$), which were greater than the improvement in wrist extension strength in the unaffected arm ($p < 0.05$). Finally, individuals with LE had less error in force reproduction and joint position reproduction (36% and 58%) at 0 min following application of transverse rigid tape ($p < 0.05$), while a healthy control group had no change in either measure following application of transverse rigid tape ($p \geq 0.05$) (Lee et al., 2011).

3.4.3. Short-term effect of therapeutic tape on pain

Two studies (Dilek et al., 2016; Shakeri et al., 2017) investigated the effects of short-term treatment with kinesiotape on pain (Fig. 4). Following four applications of facilitatory kinesiotape over two weeks, Dilek et al. (2016) revealed decreases (17%–50%) in five different patient-rated measures of pain ($p < 0.05$, Fig. 4). Compared to baseline, these outcomes were decreased by an even greater amount (33%–65%) at six weeks, following a four-week follow-up period without active intervention ($p < 0.05$). Similarly, following three applications of tape in one week, Shakeri et al. (2017) reported a 61% decrease in pain intensity during ADLs in the diamond kinesiotape group and a 22% reduction in the placebo kinesiotape group (both $p < 0.05$). Between-group comparison revealed the diamond kinesiotape group had a greater decrease in pain intensity than the placebo kinesiotape group ($p < 0.05$) (Shakeri et al., 2017). In contrast, neither group demonstrated significant improvement in PPTs or pain intensity during palpation of a myofascial trigger point of the forearm extensor muscles ($p \geq 0.05$) (Shakeri et al., 2017).

3.4.4. Short-term effect of therapeutic tape on function

Dilek et al. (2016) revealed a 29% increase in maximum grip strength following two weeks of facilitatory kinesiotape treatment, which remained 29% higher than baseline at six weeks (both $p < 0.05$). In contrast, Shakeri et al. (2017) noted no significant difference in maximum grip strength in the diamond kinesiotape or placebo kinesiotape group ($p \geq 0.05$). Dilek et al. (2016) revealed a 42% improvement in overall Patient-Rated Tennis Elbow Evaluation score following two weeks of facilitatory kinesiotape and a 51% improvement at six-weeks (both $p < 0.05$). Similarly, Shakeri et al. (2017) reported a 48% and 19% improvement in the Disability of the Arm, Shoulder and Hand (DASH) score in the diamond kinesiotape group and placebo kinesiotape group respectively (both $p < 0.05$). There was a greater improvement in DASH score in the diamond kinesiotape than the placebo kinesiotape group ($p < 0.05$) (Shakeri et al., 2017).

4. Discussion

The aim of the present review was to identify, appraise, and examine studies investigating the effects of therapeutic tape on pain and function in individuals with LE. Overall, included studies investigated two types of tape, applied using seven techniques. There were nine outcomes related to pain and eight outcomes related to function. Meta-analyses were precluded due to study heterogeneity and lack of appropriate data to calculate effect sizes.

4.1. Immediate effects of therapeutic tape

While pain and function can be reported separately, it is likely that changes in pain influence changes in function and vice versa. All studies that examined diamond deloading tape reported significant decreases in resting pain intensity (Goel et al., 2015; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013) and one of two studies reported an increase in PPTs (denoting a decrease in mechanical pain sensitivity) over the lateral epicondyle (Goel et al., 2015; Vicenzino et al., 2003). Improvements in function were also observed in all studies investigating diamond deloading tape (Goel et al., 2015; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003). These improvements could potentially be explained by a neurophysiological effect (Heinricher et al., 2009), whereby tactile stimulation of skin and subcutaneous tissue can alter nociceptive input and reduce pain (Mancini et al., 2014), and improve muscle activity (MacGregor et al., 2005). Yet, given that placebo tape applied without tension did not affect pain or function (Vicenzino et al., 2003), a mechanical effect of diamond deloading tape could be considered. Diamond deloading tape is suggested to reduce load on painful underlying structures (Vicenzino et al., 2003) and alter muscle activity (Tobin & Robinson, 2000). Although no studies have examined the mechanical effects of diamond deloading tape at the common extensor tendon, previous work using shear wave elastography has shown a reduction in tissue stiffness within diamond deloading tape over rectus femoris, at rest and during muscular contraction (Hug et al., 2014). These findings support a potential deloading effect. Although the mechanism of effect remains ambiguous, application of diamond deloading tape can immediately improve pain and function in individuals with LE.

There is some discrepancy between the two studies (Au et al., 2017; Goel et al., 2015) investigating immediate effects of kinesiotape techniques on pain and function. Goel et al. (2015) noted improvement in pain and grip strength, while Au et al. (2017) reported no change in grip strength, pain, or muscle activity following application of kinesiotape. The discrepancy could be attributed to tape technique, as both studies (Au et al., 2017; Goel

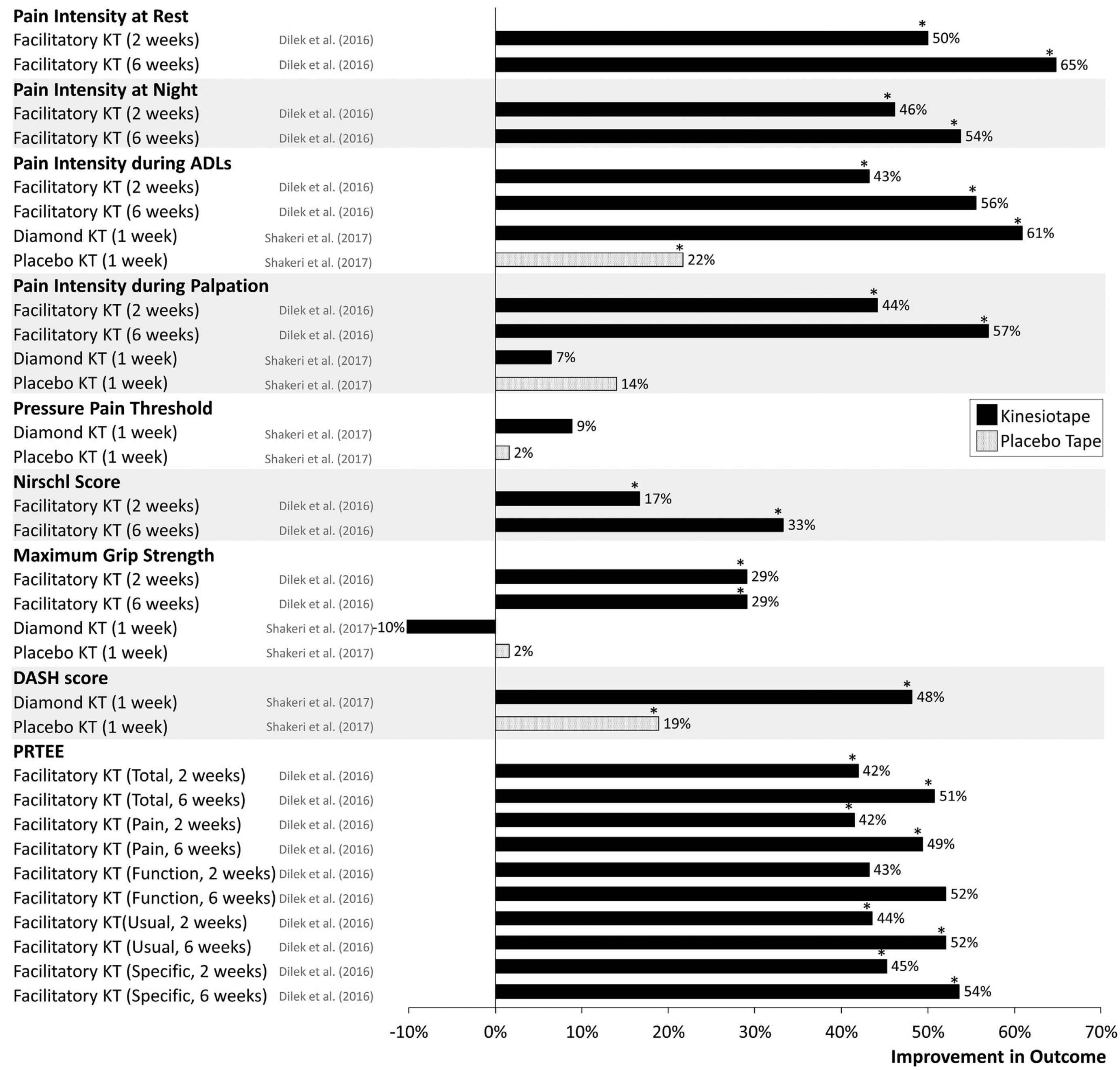

Fig. 4. Short-term treatment effects of therapeutic tape on pain- and function-related measures. Improvement in pain intensity represents decreased VAS value; improvement in PPT represents increased pressure tolerated prior to onset of pain; improvement in Nirschl, DASH, or PRTEE score represents a lower score (PRTEE subscales presented below the total score); improvement in strength represents increased force; values adjacent to bar indicate actual percentage change; ADLs – Activities of Daily Living; DASH – Disability of the Arm, Shoulder and Hand; KT – kinesiotape, PRTEE – Patient-Rated Tennis Elbow Evaluation, RT – rigid tape; *denotes significant change from baseline condition.

et al., 2015) applied a longitudinal strip of kinesiotape to forearm extensor muscles; yet, Goel et al. (2015) added a 'fascial correction' strip of tape. This transverse tape is purported to reduce pain more effectively when used to supplement longitudinal tape (Kase et al., 2003). The transverse tape could potentially simulate a counter-force brace, and potentially improve pain and pain-free grip strength when applied in a similar location (Jafarian, Demneh, & Tyson, 2009; Sadeghi-Demneh & Jafarian, 2013). Alternatively, given that significant pain-related findings of Goel et al. (2015) were not apparent until 30 min following application of tape, the difference between studies may be due to a time-dependent response. Kinesiotape is purported to have a neurophysiological effect via stimulation of pain-modulating supraspinal sites (e.g. periaqueductal gray, dorsal reticular nucleus) (Heinricher et al., 2009). Thus, 30 min could allow sufficient stimulation of skin and subcutaneous tissue to increase alpha motor neuron activity (Konishi, 2013) or descending pain inhibition (Mancini et al., 2014), and account for lack of change in pain or grip strength at 0 min in either study (Au et al., 2017; Goel et al., 2015). Based on these findings, kinesiotape may have a small time-dependent effect on submaximal measures of pain and function in individuals with LE. If clinicians choose to use kinesiotape, they could consider adding transverse tape to a longitudinal technique, and remain aware there may be a short time period before submaximal outcome improvement.

Research in LE has identified deficits in proprioception compared to healthy controls (Juul-Kristensen et al., 2008), with application of transverse rigid tape shown to improve joint position sense and force reproduction (Lee et al., 2011). Nociception is thought to have an inhibitory effect on peripheral proprioceptors (Sterling, Jull, & Wright, 2001); thus, a decrease in pain may enhance proprioceptive function. The possibility of a relationship between proprioception and pain is supported by a lack of change in proprioception in asymptomatic controls following application of tape (Lee et al., 2011). Therefore, future studies investigating proprioception should consider measuring pain to determine if a relationship exists.

4.2. Short-term effect of therapeutic tape

The present review identified two studies investigating kinesiotape as a short-term standalone treatment. While Dilek et al. (2016) used a commonly recommended technique (i.e. longitudinal kinesiotape) (Kase et al., 2003), Shakeri et al. (2017) used diamond kinesiotape, which appears to be modified from the rigid tape diamond deloading method. In contrast to rigid tape (Vicenzino, 2003), the elastic nature of kinesiotape is not intended, and possibly ill-suited, to achieve a deloading effect (Matheus et al., 2017).

The effect of kinesiotape treatment on pain in LE remains uncertain. Both treatment studies (Dilek et al., 2016; Shakeri et al., 2017) reported improvement in measures of pain intensity; yet, neither study included a wait-and-see control group, limiting the ability to detect change due to tape, rather than natural progression. In the study by Dilek et al. (2016), all five measures of pain continued to improve between the end of the treatment (at two weeks) and at six weeks follow-up, despite no active intervention during the follow-up period. Although this may suggest ongoing benefit from tape, previous work has shown patient-rated global improvement in approximately one-third of participants in a control group, also at six weeks (Bisset et al., 2006b). This improvement indicates that natural resolution of pain and function is seen within this timeframe. Furthermore, kinesiotape may have a placebo effect (Bialosky, Bishop, & Cleland, 2016). Significant improvement in pain intensity rated during ADLs in both the treatment and placebo group suggests that even non-tensioned diamond kinesiotape may influence pain (Shakeri et al., 2017). The placebo effect is observed in other studies where patients report better subjective performance following kinesiotape application, despite no objective strength increases (Vercelli et al., 2012). The effect of kinesiotape on pain is further convoluted by a lack of change to pain intensity or PPTs in either the diamond or placebo kinesiotape group (Shakeri et al., 2017). Previous systematic reviews of kinesiotape treatment for a range of musculoskeletal conditions have reported that kinesiotape can reduce pain more effectively than minimal intervention, although the change may not be clinically meaningful (Lim & Tay, 2015; Montalvo, Cara, & Myer, 2014; Parreira et al., 2014). Based on the studies in the present review, kinesiotape may be associated with improvement in some measures of pain in individuals with LE; however, well-designed randomised controlled trials with a wait-and-see group are required to establish the effects beyond natural resolution or placebo.

Patient-rated pain and disability improved following all kinesiotape interventions in the present review (Dilek et al., 2016; Shakeri et al., 2017), while maximum grip strength was the only objective measure to improve after two weeks of facilitatory kinesiotape treatment (Dilek et al., 2016). Nevertheless, examination of the findings of Dilek et al. (2016) reveals a high risk of bias; therefore, providing insufficient evidence to support use of kinesiotape to improve pain or function. Change in DASH scores (Shakeri et al., 2017) did not meet a minimum clinically important difference of ten points (Gummesson, Atroshi, & Ekdahl, 2003), suggesting one week of diamond kinesiotape treatment is unlikely to provide clinically meaningful improvements in pain and function. A lack of clinical benefit is supported by a systematic review of kinesiotape treatment for musculoskeletal injury, that revealed insufficient evidence that kinesiotape treatment elicited improved global measures of function (e.g. return to sport) (Mostafavifar, Wertz, & Borchers, 2012). This contrasts to growing evidence supporting the addition of both rigid tape and kinesiotape to a range of conservative management strategies for improving pain and function in LE (Amro et al., 2010; Eraslan et al., 2018; Sai & Shanavas, 2017; Wegener, Brown, & O'Brien, 2016), although combined interventions remain beyond the scope of the present review. Thus, there is inconclusive evidence for kinesiotape applied as a standalone intervention for functional deficits in LE.

4.3. Study considerations

The present review identified a lack of consistent high-quality evidence, with EAI scores ranging from 0.39 to 0.72, (mean = 0.51) across included studies. Although authors of the included studies were contacted (Au et al., 2017; Dilek et al., 2016; Goel et al., 2015; Shakeri et al., 2017; Shamsoddini et al., 2010; Shamsoddini & Hollisaz, 2013; Vicenzino et al., 2003), successful responses were limited. Subsequently, it was not possible to calculate effect sizes across all studies, precluding funnel plot assessment of publication bias. In line with study reporting guidelines, future studies should provide effect sizes with precision estimates to facilitate comparison between studies (Moher et al., 2010). A majority of studies lacked thorough blinding of assessors and participants, leaving the results of individual studies susceptible to bias. Blinding remains a practical challenge in therapeutic tape studies, where tactile stimulation renders it impossible for participants to remain unaware of the presence of tape (or no tape) during testing. Overall, most studies in this review are at risk of sufficient bias to advise caution when interpreting results (Higgins & Green, 2011).

4.4. Future direction

The present review has identified four key goals for future research. First, standardised reporting of study procedures, outcome measures, and statistical analyses will facilitate rigorous inter-study comparisons (Wright & Vicenzino, 1997). Additionally, well-controlled trials examining muscle function and tendon load may help elucidate the mechanisms by which therapeutic tape influences outcomes in LE. Once there is an understanding of optimal tape techniques and mechanism of effect, researchers should aim to establish ideal treatment timeframes for application of therapeutic tape. Finally, there is emerging evidence therapeutic tape may be a valuable addition to multimodal treatment in LE (Amro et al., 2010; Eraslan et al., 2018; Sai & Shanavas, 2017; Wegener et al., 2016), in line with current recommendations (Coombes et al., 2015). Examining therapeutic tape in addition to other treatments will ascertain the most efficacious interventions for individuals with LE.

5. Conclusion

The present review has highlighted the paucity of high-quality research investigating the effects of therapeutic tape in individuals with LE. Based on the included studies, application of rigid tape using a diamond deloading technique is likely to immediately improve pain and function in individuals with LE. It is unclear whether kinesiotape influences pain and function immediately or in the short-term.

Conflicts of interest

None.

Ethics approval

Not Applicable.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2019.08.011.

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