Physiotherapy 105 (2019) 412–420

Systematic review

Effects of kinesio taping alone *versus* sham taping in individuals with musculoskeletal conditions after intervention for at least one week: a systematic review and meta-analysis

Robinson Ramírez-Vélez [a,b,*], Ignacio Hormazábal-Aguayo [c], Mikel Izquierdo [a,b], Katherine González-Ruíz [d], Jorge Enrique Correa-Bautista [a], Antonio García-Hermoso [b,c]

[a] *Department of Health Sciences, Public University of Navarre, CIBERFES (CB16/10/00315), Navarre, Spain*
[b] *Navarrabiomed, IdiSNA, Pamplona, Navarre, Spain*
[c] *Laboratorio de Ciencias de la Actividad Física, el Deporte y la Salud, Facultad de Ciencias Médicas, Universidad de Santiago de Chile, USACH, Santiago, Chile*
[d] *Grupo de Ejercicio Físico y Deportes, Vicerrectoría de Investigaciones, Universidad Manuela Beltrán, Bogotá, Colombia*

Abstract

Background Kinesiotaping (KT), has emerged as an interesting and relatively novel method for treating musculoskeletal conditions. To date, none of the systematic reviews with meta-analysis have addressed the efficacy of KT alone (without any other intervention) over sham taping (ST).

Objective The present meta-analysis aimed to investigate the effectiveness of KT *versus* ST in patients with musculoskeletal conditions in interventions lasting at least 1 week on musculoskeletal conditions and functional performance outcomes.

Data source Manual and electronic searches (CENTRAL, EMBASE, MEDLINE and PEDro) were conducted using kinesiotaping, strapping, musculoskeletal pain and musculoskeletal conditions.

Study selection criteria Randomised controlled trials on adults with a diagnosis of musculoskeletal conditions.

Data extraction and data synthesis Two researchers independently carried out the search and the third author was referred to for arbitration. The methodological quality of the studies using the PEDro scale and GRADE approach.

Results Six RCTs were identified and included in the meta-analysis. When compared with ST in adults with chronic non-specific low-back pain (LBP), KT resulted in superior effects on pain at follow-up, but the pooled pain in the immediate post-treatment period and disability scores (in the immediate post-treatment period and at follow-up) were not significantly different. Generally, all results were supported by low quality evidence according to GRADE criteria.

Conclusion Our findings indicate inconclusive and low-quality evidence of a beneficial effect of KT alone over ST in LBP and knee osteoarthritis.

Systematic review registration number: PROSPERO CRD42018084151.

Keywords: Taping; Sham taping; Knee; Lower back; Evidence based; Physiotherapy

* Corresponding author at: Department of Health Sciences, Public University of Navarre, CIBERFES (CB16/10/00315), Navarre, Spain.
E-mail addresses: robin640@hotmail.com, robinson.ramirez@urosario.edu.co (R. Ramírez-Vélez), ignacio.hormazabal@usach.cl (I. Hormazábal-Aguayo), mikel.izquierdo@gmail.com (M. Izquierdo), katherine.gonzalez@docentes.umb.edu.co (K. González-Ruíz), correab.jorge@gmail.com (J.E. Correa-Bautista), antonio.garciah@unavarra.es (A. García-Hermoso).

https://doi.org/10.1016/j.physio.2019.04.001
0031-9406/

Introduction

Musculoskeletal conditions comprise more than 150 diagnoses that affect the locomotor system – that is, muscles, bones, joints and associated tissues such as tendons and ligaments and are most frequently managed in primary care [1]. This condition affects more than one out of every two individuals in the United States aged 18 and over, and nearly three out of four aged 65 and over [2]. Data from the Global Burden of Disease and the worldwide impact of all diseases and risk factors showed that musculoskeletal conditions such as arthritis and back pain affect more than 1.7 billion people worldwide, are the second greatest cause of disability, and have the fourth greatest impact on the overall health of the world's population when considering both death and disability [3].

Numerous treatments are available for musculoskeletal conditions, most of which are provided in primary care by first contact clinicians such as general practitioners, physiotherapists, chiropractors and osteopaths [4]. Treatments include kinesiology [5], medication [6], electrotherapy [7], manipulative therapy [8], and exercise therapy [9], among others [10]. Clinically, the purpose of these treatments is to relieve pain, delay complications, and prevent disease progression [11]. Nevertheless, these treatments have, at best, small to moderate short-term benefits. Accordingly, more effective treatments are needed for musculoskeletal conditions.

There is a general lack of information on the comparative effectiveness of non-pharmacological options (e.g., conservative treatments). Consequently, there is a need to evaluate current evidence regarding the best treatments for musculoskeletal conditions. Against this background, elastic therapeutic taping, also known as Kinesio® taping (KT), has emerged as an interesting and relatively novel method for treating musculoskeletal conditions [12]. The method, developed in the late 1970's, involves the application of elastic adhesive tape to the patient's skin under tension, thus placing the target muscle in a stretched position. According to Dr Kenzo Kase, the creator of the KT method [13], the mechanism can be inhibitory or excitatory, depending on the direction of tape application. Morris et al. [14] have suggested enhanced proprioception *via* increased stimulation of cutaneous mechanoreceptors as another mechanism of action for KT. Various therapeutic benefits have been proposed for KT, including facilitating motor skills, increasing muscle strength and reducing muscle fatigue, inhibiting pain, enhancing healing such as reducing lymphedema related to breast cancer, and improving lymphatic drainage and blood flow, among others [15]. This is an important issue if the authors are to provide optimal care to patients with musculoskeletal conditions, and ensure the efficient use of health care resources.

Despite its popularity, especially among athletes, and its increasing use in clinical practice, there remains clinical uncertainty over the efficiency of KT because of insufficient and inconsistent supporting evidence [16]. Previous narrative [17] and systematic [15,16,18–23] reviews of randomized controlled trials (RCTs) overall suggest that KT may have a small effect in alleviating musculoskeletal-related disorders such as arthritis, knee pain or low-back pain and may not be superior to other treatments when used as a stand alone treatment. Nevertheless, some reviews [24,25] have reported evidence for pain reduction with the use of KT.

From a methodological perspective, many of these systematic reviews [15,22,24,26] used a descriptive approach to summarize the results, whereas others [20,21,25] attempted a quantitative approach to evaluate the effects of KT on specific clinical parameters. Most of the latter studies suggested that existing evidence do not establish the superiority of KT to other treatment approaches [21] and do not support the use of this intervention in musculoskeletal clinical populations [20]. However, due to the heterogeneity in the interventions (such as KT plus therapeutic exercise or physical therapy, *etc*.) and the group comparisons (control group, physical therapy [hot pack, ultrasound, TENS], ST, therapeutic exercise, *etc*.), it is difficult to draw conclusive results. To date, none of the systematic reviews with meta-analysis have addressed the efficacy of KT alone (without any other intervention) *versus* sham taping (ST) (i.e. placebo taping).

For these reasons, the authors recognized the need for an up-to-date and specific systematic review and meta-analysis to evaluate the effectiveness of KT alone *versus* ST in patients with musculoskeletal conditions in primary care (i.e., back and knee as indicated by Jordan [27], in interventions lasting at least 1 week). This systematic review expands upon previous studies [15,16,18,20,22,26,28] by considering KT alone.

Methods

Protocol and registration

The study was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [29]. The review was registered with PROSPERO (CRD42018084151) at the University of York, UK. However, no study protocol was published before the initiation of the meta-analysis. All analyses were based on aggregate data from previously published studies, and thus, no ethical approval was required.

Eligibility criteria

The inclusion criteria for the study were the following: (1) adults aged ≥18 years; (2) RCT in humans; (3) patients with musculoskeletal conditions; (4) interventions using KT compared with a ST group, without other forms of intervention (therapeutic exercise, physical therapy, *etc*.); (5) duration of intervention (tape worn *in situ*) of at least 1 week; and (6) containing musculoskeletal conditions (e.g. pain) and functional performance (e.g. muscle strength, range of motion, disability, *etc*.) outcomes. Eligibility assessment for all reports was done by two reviewers (IH-A and AG-H). Disagreements were discussed and, if necessary, a third reviewer (RR-V) was referred to for arbitration.

Information sources

A literature search was performed using the electronic databases Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, MEDLINE and Physiotherapy Evidence Database (PEDro) (all: from inception to 15 January 2018).

Study search

Two researchers (IH-A and AG-H) independently carried out the search. The limits applied included 'humans' and 'randomized controlled trials', and the search terms used were the following: ['kinesio taping' OR 'elastic taping' OR 'kinesio-taping' OR 'kinesio tape' OR 'kinesiotape' OR adj2 taping; 'taping and strapping' OR 'musculoskeletal pain' and 'musculoskeletal conditions']. Detailed search strategies used in each database are described in supplementary file 1. The electronic search was supplemented by a manual review of reference lists of eligible studies to identify and evaluate other articles. Studies reported in languages other than English were not explored.

Study selection

Two reviewers (IH-A and AG-H) independently screened the titles and abstracts of potentially eligible studies identified through the search strategy. If necessary, a third reviewer (RR-V) was consulted. The bibliographic management software EndNote version X7.0 for Windows was used for all searches. Any differences in opinion between the two authors were discussed and, if necessary, the third author was referred to for arbitration. Reasons for exclusion of identified articles were recorded in all cases.

Data collection process and data items

Two reviewers (IH-A and AG-H) independently abstracted all data. For each study, data were extracted regarding the first author's last name, year of publication, characteristics of the subjects (age, symptom duration, use of medication), KT and ST characteristics (frequency, duration of each tape worn *in situ*, and amount of tension applied), follow-up times, outcomes assessment, sample size, and mean values with corresponding standard deviations of outcomes (pre- and post-test). The reviewers created a study-specific speadsheet in Excel (Microsoft Corp., USA) for data collection. Any disagreements between the two reviewers were discussed and, if necessary, the third author was referred to for arbitration.

Risk of bias of individual studies

The authors assessed the methodological quality of the studies using the 11-item PEDro scale [30] by evaluating the domains of population, treatment allocation, blinding, prognostic comparability and analysis.

The authors appraised the quality of the evidence using the GRADE approach, which evaluates the quality of evidence for outcomes (meta-analysis) reported in systematic reviews [31]. In addition, it is a systematic and explicit approach that allows judgements to be made about the strength of evidence and is therefore an effective method for linking evidence quality and clinical recommendations. The GRADE approach specifies four levels of quality (high, moderate, low and very low). The overall quality of evidence was initially regarded as "high" but was downgraded by one level for each of the five factors the authors encountered: risk of bias (>25% of participants from studies with low quality methods), inconsistency (substantial I^2 statistic), indirectness (e.g., whether participants are similar to those about whom conclusions are drawn), imprecision (based on the confidence interval estimator and the number of events or the number of subjects included), and other considerations (publication bias). Single randomized studies (with under 300 participants) were considered inconsistent and imprecise (that is, sparse data) and provided 'low quality evidence' [16]. This could be further downgraded to 'very low quality evidence' if there were also limitations in design. Each study and GRADE [31] quality was assessed by two reviewers (IH-A and AG-H), and any discrepancy in the final grade was resolved through group discussion or discussion among the primary authors. The authors used the following definitions of quality of evidence: high quality—further research is unlikely to change our confidence in the estimate of effect; moderate quality—further research is likely to have an important impact on our confidence in the estimate of effect and might change the estimate, that is, one of the domains was not fulfilled; low quality—further research is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate, that is, two of the domains were not fulfilled; lastly, very low quality—the authors are uncertain about the estimate, that is, three of the domains were not fulfilled [16].

Summary measures

Where appropriate and possible, the authors calculated the standardized mean difference expressed as Hedges' g statistic, to correct for possible small-sample bias and to account for differing outcome scales used in the studies [32]. Analysis was carried out using Comprehensive Meta-analysis Software v.2.0 (Biostat, Englewood, NJ, USA). The Hedges' g statistic of the outcomes from pre- to post-intervention [33] between groups (KT *vs* ST) in each study was calculated and pooled using a random effects model (DerSimonian-Laird approach). For studies where means and standard deviations

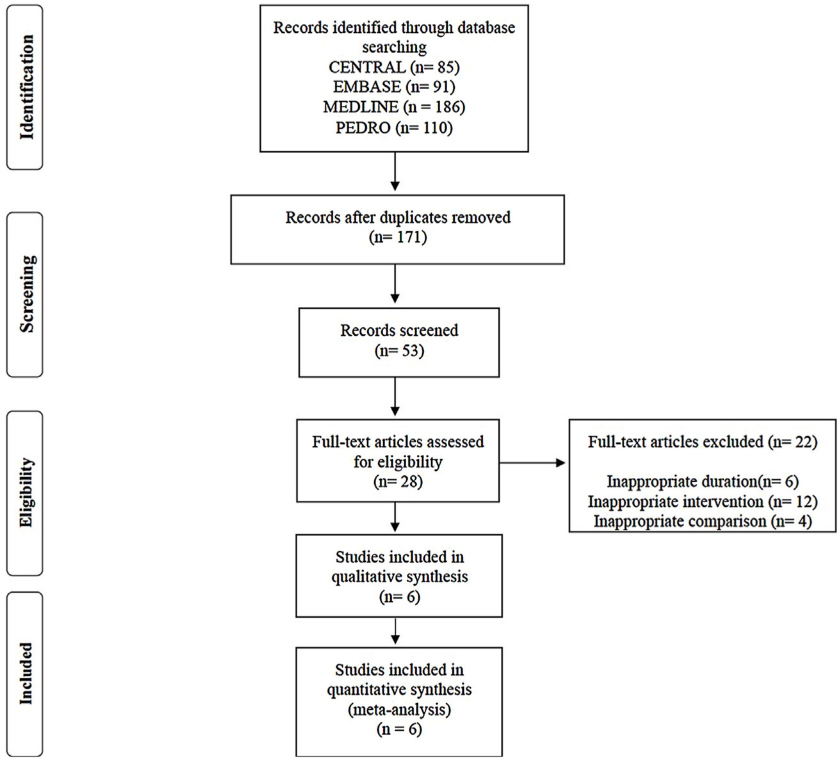

Fig. 1. Flow chart for the identification of the studies included in the systematic review and meta-analysis.

were not reported and could not be obtained from the authors, the authors transformed dichotomous data into the standardized mean difference using the formulas implemented in Comprehensive Meta-analysis [34], or used other statistics such as t-values or exact p-values to calculate the standardized mean difference.

For the placebo group, the Hedges' g statistic was calculated as the mean pre- to post-intervention in each study (i.e., in all cases the pre- and post-intervention data were used in the meta-analysis), divided by the pooled standard deviation, and correcting for small sample bias.

Synthesis of results

Statistical heterogeneity across the various trials was tested with Cochran's Q test [35] and the I^2 statistic. I^2 values of <25%, 25–50%, and >50% are considered to represent small, medium, and large degrees of heterogeneity [36]. Each study was deleted from the model once to analyze its influence on the overall results.

Risk of bias across studies

Small-study bias was assessed using Egger's test of the intercept to test the symmetry of the funnel plot [37].

Additional analysis

When appropriate and possible, random-effects meta-regression analyses were used to evaluate whether the results differed with duration of each tape worn *in situ* [38]. The effect of individual studies on the pooled Hedges' g was assessed with influence analysis, in which the analysis was repeated omitting one study at a time, to establish the contribution of each study to the effect size.

Results

Study selection

A total of 472 studies were identified through the database search. The titles and abstracts of the returned articles were examined for suitability, leading to the retrieval of 28 full texts. Of those 28, 22 were rejected—12 because of the type of intervention criterion (interventions with exercise, manual therapy, *etc*.), six because of the duration of the intervention (<1 week), four because of the comparison group (control group not ST). Six RCTs met the inclusion criteria and were included in the meta-analysis [39–44]. A flow diagram summarizing the study selection process of the systematic review and meta-analysis is shown in Fig. 1. Exclusion criteria and the list of excluded articles are in supplementary file 2.

Study characteristics

The characteristics of the six RCTs included in the systematic review sorted by study design are shown in Table 1. The six studies included 544 participants. Sample sizes ranged from 39 [43] to 148 participants [44]. Participants age ranged

Table 1
Results and conclusions of studies of kinesio taping *versus* sham taping.

Study and condition	Groups	Mean age (SD) and sex (%)	Intervention	Time of intervention	Assessment	Conclusions	PEDro score
Al-Shareef et al. (2016) [39] Low back pain	KT, $n = 21$ ST, $n = 23$	KT, 38 (10) ST, 36 (8) 50% females	Two I-shaped tapes of cure tape type (width 5 cm, and 0.5 mm thickness) were applied on the erector spinae paravertebral muscles (bilaterally) parallel to the spinous processes of the lumbar spine with 10 to 15% of tension	2 weeks Follow up at 4 weeks	Visual Analogue Scale Oswestry Disability Index Range of Motion: Trunk Flexion	Kinesio taping reduces pain and disability and improves trunk flexion range of motion after two weeks of application	7
Araujo et al. (2018) [40] Low back pain	KT, $n = 73$ ST, $n = 72$	KT, 51 (15) ST, 50 (15) 68% females	I-shaped kinesio tape over each erector spinae muscle with 10 to 15% of tension (paper-off tension) with the treated muscles in stretched position	Follow up at 6 weeks	Visual Analogue Scale Roland Morris Disability Questionnaire Global Impression of Recovery	Four weeks of kinesio taping treatment was not better than sham taping for patients with chronic low back pain, at 6 months follow-up	8
Castro-Sanchez et al (2012) [41] Low back pain	KT, $n = 30$ ST, $n = 29$	KT, 50 (15) ST, 47 (13) 68% females	Four blue I-strips placed at 25% tension overlapping in a star shape (the central part adheres before the ends) over the point of maximum pain in the lumbar area	1 week Follow up at 5 weeks	Oswestry Disability Index Roland-Morris Disability Questionnaire Visual Analogue Scale Range of Motion: Trunk Flexion Tampa Scale for Kinesiophobia	Kinesio taping reduced disability and pain in people with chronic non-specific low back pain, but these effects may be too small to be clinically worthwhile	9
Kocyigit et al. (2015) [42] Knee osteoarthritis	KT, $n = 21$ ST, $n = 20$	KT, 52 (8) ST, 52 (10) 78% females	Patients were taped with a Y-shaped kinesio type at the quadriceps femoris with 25% of tension	12 days	Visual Analogue Scale Lequesne index score Nottingham Health Profile	Our findings indicate inconclusive evidence of a beneficial effect of kinesio taping over sham taping in knee osteoarthritis	8
Mutlu et al. (2017) [43] Knee osteoarthritis	KT, $n = 20$ ST, $n = 19$	KT, 54 (6) ST, 57 (6) 85% females	Patients were taped with a Y-shaped Kinesio type at the quadriceps femoris with 25% of tension	3 weeks Follow up at 12 weeks	Visual Analogue Scale Aggregated Locomotor Function The Western Ontario and McMaster Universities Osteoarthritis scale Range of motion Muscle Strength	This study demonstrates that kinesio taping resulted in superior short-term effects on walking task, pain, and knee-flexion ROM compared with placebo taping in patients with knee osteoarthritis	8
Parreira et al (2014) [44] Low back pain	KT, $n = 74$ ST, $n = 74$	KT, 51 (15) ST, 50 (15) 68% females	I-shaped kinesio tape over each erector spinae muscle with 10 to 15% of tension (paper-off tension) with the treated muscles in stretched position	4 weeks Follow up at 12 weeks	Visual Analogue Scale Roland Morris Disability Questionnaire Global Perceived Effect	Kinesio taping applied with stretch to generate convolutions in the skin was no more effective than simple application of the tape without tension for the outcomes measured. These results challenge the proposed mechanism of action of this therapy	9

KT, kinesio taping; SD, standard deviation; ST, sham taping

Study name	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Al-Shareef 2016	-1.967	0.363	0.132	-2.678	-1.255	-5.417	0.000
Castro-Sanchez 2012	-1.128	0.277	0.077	-1.671	-0.585	-4.069	0.000
Parreira 2014	-0.150	0.164	0.027	-0.471	0.171	-0.915	0.360
Pain (post-treatment period)	-1.044	0.534	0.285	-2.091	0.002	-1.956	0.051
Al-Shareef 2016	-2.221	0.379	0.144	-2.964	-1.477	-5.854	0.000
Araujo 2016	-0.283	0.166	0.028	-0.609	0.042	-1.706	0.088
Castro-Sanchez 2012	-0.775	0.267	0.071	-1.298	-0.253	-2.907	0.004
Parreira 2014	-0.203	0.164	0.027	-0.524	0.118	-1.238	0.216
Pain (follow-up)	-0.790	0.329	0.109	-1.436	-0.144	-2.398	0.016
Al-Shareef 2016	-0.311	0.298	0.089	-0.896	0.273	-1.043	0.297
Castro-Sanchez 2012	-0.837	0.268	0.072	-1.362	-0.311	-3.118	0.002
Parreira 2014	-0.030	0.164	0.027	-0.350	0.291	-0.183	0.855
Disability (post-treatment period)	-0.362	0.252	0.064	-0.856	0.132	-1.437	0.151
Al-Shareef 2016	-0.279	0.298	0.089	-0.863	0.305	-0.936	0.349
Araujo 2016	-0.183	0.166	0.027	-0.508	0.141	-1.107	0.268
Castro-Sanchez 2012	0.000	0.257	0.066	-0.504	0.504	0.000	1.000
Parreira 2014	0.046	0.164	0.027	-0.274	0.367	0.284	0.776
Disability (follow-up)	-0.081	0.100	0.010	-0.276	0.115	-0.808	0.419

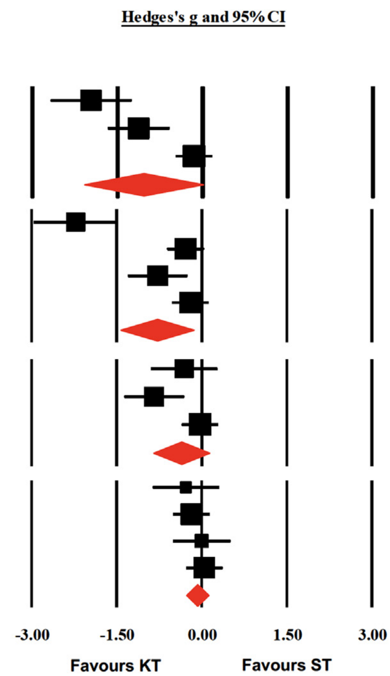

Fig. 2. Forest plot for changes in pain, disability and range of motion in patients with LBP. The black horizontal lines represent the 95% confidence intervals while the squares represent the Hedge's g estimate. The red diamonds represent the overall point estimate and 95% confidence intervals from all individual studies included in each meta-analysis. All analyses are based on the random-effects model. KT, kinesio taping; ST, sham taping. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

from 36 [39] to 57 years [43]. The majority of the patients were female (69%). Studies were conducted in Brazil [40,44], Saudi Arabia [39], Spain [41], and Turkey [42,43].

Four studies concerned LBP [39–41,44] and two concerned knee osteoarthritis [42,43]. All the studies on LBP comprised individuals with chronic non-specific LBP, with symptom duration of at least 3 months. The studies on knee pain diagnosed knee osteoarthritis according to clinical diagnostic criteria proposed by America College of Rheumatology.

Regarding tape application, all studies used elastic taping. The length of interventions ranged from 1 to 3 weeks and 5 to 12 days to 6 weeks from randomization, respectively.

One study [39] applied the KT from the insertion to the origin of the muscle, two studies applied it from the origin to insertion direction [42,43], while the remaining studies [40,41,44] did not report details regarding the taping direction.

Outcomes measures

Pain intensity was measured in all studies using a visual analogue scale (VAS), even including for rest pain [43], nocturnal pain [42,43], and activity pain [42,43]. Disability was measured using the Oswestry Disability Index [39,41] or the Roland Morris Disability Questionnaire [40,41,44]. Range of motion was measured in three RCTs [39,41,43]. Other measures used were the Global Impression of Recovery [40], the Global Perceived Effect [44], Lequesne index score [42], the Western Ontario and McMaster Universities Osteoarthritis scale [43], Aggregated Locomotor Function [43], Nottingham Health Profile [42], and muscle strength [43].

Risk of bias within studies

The methodological quality assessment using the PEDro scale revealed a mean score of 8.2 (range 7–9) of a possible 10 points (Table 1). Criteria commonly not met were blinding of treating therapists and patients. Overall, the quality of evidence (GRADE) completed for each pooled estimate and for single trials comparing KT with sham intervention was 'low quality' and 'very low quality', except for disability at follow-up with a 'moderate quality' (supplementary file 3).

Synthesis of results

Data were pooled using a random effects model in patients with LBP. There was a significant pooled Hedges' g in pain at follow-up between the KT and ST groups. By contrast, there was no significant pooled Hedges' g in pain in the immediate post-treatment period, disability in the immediate post-treatment period, and disability at follow-up between the KT *versus* ST groups (Fig. 2).

Finally, when both groups are analyzed independently, KT and ST group also showed a medium and large effect on all outcomes except for ST on disability in the immediate post-treatment period (Table 2).

Table 2
Synthesis of results for LBP.

	n	Effect size (g)	95% CI	*P*	I^2	Egger test (p)
KT *versus* ST						
Pain (post-treatment period)	3	−1.044	−2.091 to 0.002	0.051	92.18	0.020
Pain (follow-up)	4	−0.790	−1.436 to −0.144	0.016	88.77	0.031
Disability (post-treatment period)	3	−0.362	−0.856 to 0.132	0.151	69.99	0.442
Disability (follow-up)	4	−0.081	−0.276 to 0.115	0.419	0	0.682
KT (pre and post data)						
Pain (post-treatment period)	3	−0.982	−1.475 to −0.490	<0.001	86.13	0.146
Pain (follow-up)	4	−1.302	−1.919 to −0.684	<0.001	81.29	0.412
Disability (post-treatment period)	3	−0.546	−0.734 to −0.358	<0.001	0	0.313
Disability (follow-up)	4	−0.795	−1.276 to −0.314	0.001	87.09	0.025
ST (pre and post data)						
Pain (post-treatment period)	3	−0.843	−1.809 to −0.122	0.047	94.26	0.830
Pain (follow-up)	4	−0.581	−1.085 to −0.077	0.024	89.29	0.509
Disability (post-treatment period)	3	−0.296	−0.933 to 0.341	0.363	89.68	0.867
Disability (follow-up)	4	−0.759	−1.283 to −0.236	0.004	89.40	0.127

KT, kinesio taping; ST, sham taping.

Risk of bias across studies

Egger's linear regression tests provided evidence for the existence of small-study effects for pain in the immediate post-treatment period and pain at follow-up. By contrast, there was no evidence for the existence of small-study effects for disability in the immediate post-treatment period and disability at follow-up (Table 2).

Additional analysis

The independent effects of potential moderating variables were examined using meta-regression, showing that there was no greater decrease in pain in the immediate post-treatment period ($\beta = 0.048$; $P = 0.305$), pain in the follow-up ($\beta = 0.034$; $P = 0.596$), disability in the immediate post-treatment period ($\beta = 0.039$; $P = 0.309$), and disability in the follow-up ($\beta = 0.009$; $P = 0.505$) according to each tape applied *in situ*.

Finally, in the sensitivity analysis, with each study removed from the model individually, the results remained constant for pain with not statistically significant changes across deletions. However, for disability, after remove two studies, significant results disappear [39,41].

Discussion

Overall, our meta-analysis of relevant RCTs on LBP shows that KT not provide superior effects on pain and disability scores or trunk flexion range of motion, compared with sham intervention. Our findings are therefore similar to those of previous systematic reviews and meta-analyses, also considering the low levels of evidence. In contrast to previous meta-analyses, the six criteria for inclusion in the present study were restrictive in order to achieve a homogeneous sample of studies. However, despite the fact that most studies included duration of symptoms ≥3 months (patients may respond differently to KT), the application was heterogeneous in terms of methodology, treatment 'dosage' and type of KT. Also, despite the risk of bias within studies being low, the overall quality of evidence for most comparisons ranged from 'very low'- to 'low-quality', the heterogeneity was high, and the number of RCTs for each comparison small; therefore our results should be interpreted with caution. Suggestions for future research would be to conduct high quality RCT with longer follow-up times and sufficiently large and generalizable samples.

Conflicting results emerged from single trials because the ST group showed significant improvement in several above-mentioned parameters in patients with LBP (pain in the immediate post-treatment period and follow up, and disability at follow-up). Thus, the results of this systematic review and meta-analysis for KT do not provide any firm support for its effectiveness.

Regarding the individual risk of bias, assessed by PEDro score, it was generally high in both musculoskeletal conditions. Studies on knee osteoarthritis were homogeneous for outcome measures and age of included participants. Nevertheless, only one study [39] in LBP included participants younger than 40 years and sample size less than 50 participants per group, which is the minimum number needed to achieve 'golden' and 'platinum' evidence [45].

In light of our results, the current literature does not support the use of this therapeutic option in LBP patients, and it does not confirm the greater hypothesized effect of KT over ST. Finally, as the overall quality of the small body of literature on the effects of KT is low, future research may alter current estimates of effect, and stronger evidence could very well change confidence in our conclusions as well as to further confirm them.

Limitations

Limitations of the review include the small number of RCTs and the relatively small sample size used, especially in the knee osteoarthritis analysis. Also, the lack of a true control group was another limitation among the studies. Although all studies used an ST group, it is unclear if the pure application of tape alone caused participants to report a therapeutic effect, especially in subjective outcome measures such as pain or disability scores. Incorporating a true control group would be useful to determine whether there was a placebo effect. However, a previous study comparing KT *versus* a true control group (an 'advice and stay active group') [46] showed a very small effect considered clinically relevant to patients, although it was statistically significant [47].

Despite the frequent use of KT as a therapeutic tool for musculoskeletal rehabilitation, our findings indicate inconclusive and low-quality evidence of a beneficial effect of KT alone over ST in LBP patients. Paradoxically, the ST group also showed significant improvement in several parameters in patients with LBP. Future research requires an adequate and generalized sample size and sample population, and the investigation of the potential long-term benefits of KT application.

Key messages
Despite the frequent use of KT as a therapeutic tool for musculoskeletal rehabilitation, our findings indicate inconclusive and low-quality evidence of a beneficial effect of KT alone over ST in patients with LBP.
Paradoxically, when both groups are analyzed independently, KT and ST group (pre-post analysis) showed significant improvement in several parameters in patients with LBP.

Ethics approval: All analyses were based on aggregate data from previously published studies, and thus, no ethical approval was required.

Funding: None.

Conflict of interest: The authors declare that they have no competing interests.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.physio.2019.04.001.

References

[1] Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, Ezzati M, *et al.* Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(9859):2163–96.
[2] United States Bone and Joint Initiative. The burden of musculoskeletal diseases in the United States. 3rd ed. Rosemont (IL): United States Bone and Joint Initiative; 2014.
[3] Hay S. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016; 2017.
[4] WHO Scientific group. The burden of musculoskeletal conditions at the start of the new millennium. World Health Organ Tech Rep Ser, 919; 2003. p. 1–218.
[5] Hutting N, Oswald W, Staal JB, Engels JA, Nouwens E, Nijhuis van-der Sanden MW, *et al.* Physical therapists and importance of work participation in patients with musculoskeletal disorders: a focus group study. BMC Musculoskelet Disord 2017;18:196.
[6] Bannwarth B. Drug-induced musculoskeletal disorders. Drug Saf 2007;30:27–46.
[7] van der Windt DA, van der Heijden GJ, van den Berg SG, ter Riet G, de Winter AF, Bouter LM. Ultrasound therapy for musculoskeletal disorders: a systematic review. Pain 1999;81:257–71.
[8] Southerst D, Yu H, Randhawa K, Côté P, D'Angelo K, Shearer HM, *et al.* The effectiveness of manual therapy for the management of musculoskeletal disorders of the upper and lower extremities: a systematic review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. Chiropr Man Therap 2015;23:30.
[9] Smidt N, de Vet HC, Bouter LM, Dekker J, Arendzen JH, de Bie RA, *et al.* Effectiveness of exercise therapy: a best-evidence summary of systematic reviews. Aust J Physiother 2005;51(2):71–85.
[10] Savigny P, Kuntze S, Watson P, Underwood M, Ritchie G, Cotterell M, *et al.* Low back pain: early management of persistent non-specific low back pain. London: National Collaborating Centre for Primary Care and Royal College of General Practitioners; 2009. p. 14.
[11] Ernstzen DV, Louw QA, Hillier SL. Clinical practice guidelines for the management of chronic musculoskeletal pain in primary healthcare: a systematic review. Implement Sci 2017;12:1.
[12] Kamper SJ, Henschke N. Kinesio taping for sports injuries. Br J Sports Med 2013;47(17):1128–9.
[13] Kase K, Kase T, Wallis J. Clinical therapeutic applications of the Kinesio taping methods: Kenzo Kase; 2003.
[14] Murray H. Effect of kinesio taping on proprioception in the ankle. J Orthop Sports Phys Ther 2001;31:A–37.
[15] Morris D, Jones D, Ryan H, Ryan CG. The clinical effects of Kinesio® Tex taping: a systematic review. Physiother Theory Pract 2013;29:259–70.
[16] Vanti C, Bertozzi L, Gardenghi I, Turoni F, Guccione AA, Pillastrini P. Effect of taping on spinal pain and disability: systematic review and meta-analysis of randomized trials. Phys Ther 2015;95(4):493–506.
[17] Banerjee G, Briggs M, Johnson MI. Kinesiology taping as an adjunct for pain management: a review of literature and evidence. Indian J Pain 2016;30:151.
[18] Williams S, Whatman C, Hume PA, Sheerin K. Kinesio taping in treatment and prevention of sports injuries: a meta-analysis of the evidence for its effectiveness. Sports Med 2012;42:153–64.
[19] Desjardins-Charbonneau A, Roy JS, Dionne CE, Desmeules F. The efficacy of taping for rotator cuff tendinopathy: a systematic review and meta-analysis. Int J Sports Phys Ther 2015;10:420.

[20] Parreira PdCS, Costa LdCM, Junior LCH, Lopes AD, Costa LO. Current evidence does not support the use of kinesio taping in clinical practice: a systematic review. J Physiother 2014;60:31–9.
[21] Lim ECW, Tay MGX. Kinesio taping in musculoskeletal pain and disability that lasts for more than 4 weeks: is it time to peel off the tape and throw it out with the sweat? A systematic review with meta-analysis focused on pain and also methods of tape application. Br J Sports Med 2015;49:1558–66.
[22] Bassett KT, Lingman SA, Ellis RF. The use and treatment efficacy of kinaesthetic taping for musculoskeletal conditions: a systematic review. N Z J Physiother 2010;38:56–62.
[23] Nelson NL. Kinesio taping for chronic low back pain: a systematic review. J Bodyw Mov Ther 2016;20:672–81.
[24] Kalron A, Bar-Sela S. A systematic review of the effectiveness of kinesio taping—fact or fashion? Eur J Phys Rehabil Med 2013;49:699–709.
[25] Montalvo AM, Cara EL, Myer GD. Effect of kinesiology taping on pain in individuals with musculoskeletal injuries: systematic review and meta-analysis. Phys Sportsmed 2014;42:48–57.
[26] Mostafavifar M, Wertz J, Borchers J. A systematic review of the effectiveness of kinesio taping for musculoskeletal injury. Phys Sportsmed 2012;40:33–40.
[27] Jordan KP, Kadam UT, Hayward R, Porcheret M, Young C, Croft P. Annual consultation prevalence of regional musculoskeletal problems in primary care: an observational study. BMC Musculoskelet Disord 2010;11(1):144.
[28] Moore R. What is the current evidence for the use of kinesio tape. A literature review. Sport Dyn 2012;34:24–30.
[29] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, *et al.* The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med 2009;6(7):e1000100.
[30] de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. Aust J Physiother 2009;55:129–33.
[31] Guyatt GH, Oxman AD, Kunz R, Woodcock J, Brozek J, Helfand M, *et al.* GRADE guidelines: 7. rating the quality of evidence—inconsistency. J Clin Epidemiol 2011;64:1294–302.
[32] Cochrane handbook for systematic reviews of interventions version 5.1.0 [updated March 2011]. In: Higgins JPT, Green S, eds. The Cochrane Collaboration; 2011. Available from: www.cochrane-handbook.org. Accessed February 5, 2018.
[33] Morris SB. Estimating effect sizes from pretest–posttest-control group designs. Organ Res Methods 2008;11:364–86.
[34] Borenstein M, Hedges LV, Higgins J, Rothstein HR. Introduction to Meta-Analysis. Wiley Online Library; 2009.
[35] Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557.
[36] Higgins J, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002;21:1539–58.
[37] Egger M, Smith GD, Schneider M, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ 1997;315:629–34.
[38] Thompson SG, Sharp SJ. Explaining heterogeneity in meta-analysis: a comparison of methods. Stat Med 1999;18:2693–708.
[39] Al-Shareef AT, Omar MT, Ibrahim AH. Effect of kinesio taping on pain and functional disability in chronic nonspecific low back pain: a randomized clinical trial. Spine 2016;41:E821–8.
[40] Araujo AC, Parreira PdCS, Junior LCH, da Silva TM, da Luz Junior MA, da Cunha Menezes Costa L, *et al.* Medium term effects of kinesio taping in patients with chronic non-specific low back pain: a randomized controlled trial. Physiotherapy 2018;104:149–51.
[41] Castro-Sánchez AM, Lara-Palomo IC, Matarán-Peñarrocha GA, Fernández-Sánchez M, Sánchez-Labraca N, Arroyo-Morales M. Kinesio taping reduces disability and pain slightly in chronic non-specific low back pain: a randomised trial. J Physiother 2012;58:89–95.
[42] Kocyigit F, Turkmen MB, Acar M, Guldane N, Kose T, Kuyucu E, *et al.* Kinesio taping or sham taping in knee osteoarthritis? A randomized, double-blind, sham-controlled trial. Complement Ther Clin Pract 2015;21:262–7.
[43] Mutlu EK, Mustafaoglu R, Birinci T, Razak Ozdincler A. Does kinesio taping of the knee improve pain and functionality in patients with knee osteoarthritis? A randomized controlled clinical trial. Am J Phys Med Rehabil 2017;96:25–33.
[44] Parreira PdCS, Costa LdCM, Takahashi R, Hespanhol Junior LC, Luz Junior MA, Silva TM, *et al.* Kinesio taping to generate skin convolutions is not better than sham taping for people with chronic non-specific low back pain: a randomised trial. J Physiother 2014;60:90–6.
[45] Fransen M, McConnell S, Hernandez-Molina G, Reichenbach S. Exercise for osteoarthritis of the hip. Cochrane Database Syst Rev 2009;3(3).
[46] Kelle B, Güzel R, Sakallı H. The effect of kinesio taping application for acute non-specific low back pain: a randomized controlled clinical trial. Clin Rehabil 2016;30(10):997–1003.
[47] Ranganathan P, Pramesh C, Buyse M. Common pitfalls in statistical analysis: clinical versus statistical significance. Perspect Clin Res 2015;6:169–70.

Available online at www.sciencedirect.com

ScienceDirect