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Kinesio Taping applied to lumbar muscles influences clinical and electromyographic characteristics in chronic low back pain patients

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***Background*. Kinesio Taping (KT) has proved to be effective in various musculoskeletal conditions. Although its precise working mechanism has yet to be fully understood, it is believed to interact with neuromuscular function through mechanoceptor activation. No studies designed to assess the effects of KT in chronic low back pain (CLBP) patients have yet been conducted.**

***Aim*. The aim of this study was to determine the effects of KT on pain, disability and lumbar muscle function in sufferers of CLBP, both immediately and at a one-month follow-up examination.**

***Design*. The study consisted of two phases: phase I was based on an intra-subject pre-test/post-test procedure; phase II was based on a randomized, single-blinded controlled trial.**

***Setting*. Outpatient facility.**

***Population*. Thirty-nine CLBP patients were enrolled.**

***Methods*. KT plus exercise, KT alone or exercise alone have been used for four weeks. Pain, disability and lumbar muscle function were evaluated before and after the treatment period.**

***Results*. The patients in all three groups displayed a significant reduction in pain after treatment, though only the exercise-alone group displayed reduced disability. A return to normal lumbar muscle function was observed in 28% of patients, but was not related to a reduction in pain.**

***Conclusion*. When applied to CLBP patients, KT leads to pain relief and lumbar muscle function normalization shortly after its application; these effects persist over a short follow-up period.**

***Clinical rehabilitation impact*. KT may represent an effective adjunct therapy in the physical rehabilitation program of CLBP patients for immediate and acute pain control.**

KEY WORDS: Low back pain - Muscle, skeletal, physiology - Sports medicine, methods - Exercise.

Flexion-relaxation (FR) refers to a normal pattern of muscle activity during trunk flexion, in which the lumbar muscles initially contract, but ultimately relax, at what appears to be a distinct point in the flexion range of motion (ROM).[1] Chronic low back pain (CLBP) patients often fail to achieve FR,[2-5] and consequently display higher levels of disability.[6] Persistent activation of the lumbar musculature in CLBP subjects may represent the body's attempt to stabilize abnormal spinal structures in an attempt to avoid pain.[7] FR can be used to assess improvement objectively in CLBP patients insofar as it is responsive to functional improvement, pain reduction and active lumbar ROM measurement.[8] One interesting and relatively new method for treating musculoskeletal conditions is the application of Kinesio Taping (KT), an elastic tape that can be stretched to 140% of its original length, thereby exerting constant shear force on the skin. KT was conceived to be therapeutic and,

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according to its creators, yields the following results: 1) it corrects muscle function by strengthening weak muscles; 2) it improves blood and lymph circulation by eliminating tissue fluid or bleeding beneath the skin through muscle movement; 3) it reduces pain through neurological suppression; 4) it corrects misaligned joints by retrieving muscle spasm.[9] Although the full mechanism of action of KT has yet to be fully understood, it has successfully been applied in a number of clinical conditions. It appears to provide pain relief and increase cervical ROM in patients with acute whiplash.[10] When applied to baseball players with shoulder impingement syndrome, KT has yielded positive changes in scapular motion and muscle performance,[11] while in subjects with rotator cuff tendonitis, its application has resulted in an immediate improvement in shoulder abduction pain if compared with a non-stretch tape.[12] When applied to the patient's trunk, KT increases active lumbar flexion.[13] We hypothesized that the application of KT on the lumbar paraspinal muscles of CLBP patients interferes with muscle function, thereby influencing the FR pattern and back pain. On the basis of this hypothesis, the aims of our study were: 1) to determine whether the application of KT has an immediate effect, in terms of pain reduction and FR normalization, in a population of CLBP patients that fail to achieve FR; 2) to detect, in the same population, the effect of KT, used either in combination with exercise or on its own, on pain relief and reduced disability over a short follow-up period.

Materials and methods

Male and female patients aged between 30 and 80 with CLBP, defined as back pain lasting >12 weeks, were enrolled. In order to be included patients also had to fail to achieve FR in the lumbar muscles during trunk flexion. Exclusion criteria were: clinical signs of radiculopathy, lumbar stenosis, spondylolisthesis, previous spinal surgery, corticosteroid treatment in the last two weeks, and central and/or peripheral nervous system diseases. CLBP intensity was evaluated by means of a 10-cm horizontal visual-analog-scale (VAS) (0 cm: "no pain"; 10 cm: "worst pain I have ever had"). Subjects were asked to answer the question: "referring to the worst pain you have experienced in your life, what was the relative mean level of your back pain in the last 24 hours?" by placing a mark somewhere along the line. At each follow-up examination, the percentage of pain reduction for each patient was calculated in relation to the baseline. Patients were classified as responders (VAS_R) if pain was reduced by ≥30%, and as non-responders (VAS_{NR}) if pain was reduced by <30%.[14] The Italian version of the Roland Morris Disability Questionnaire (RMDQ),[15] which provides a numerical score ranging from 0 (no disability) to 24 (severe disability), was used to assess CLBP-related disability. At T3, the reduction in the percentage of disability for each patient was calculated in relation to the baseline. Patients were classified as responders if their RMDQ score dropped by ≥50%, and as non-responders if their RMDQ score dropped by <50%. To evaluate FR, surface electromyographic (sEMG) signals were acquired with a sampling rate of 1.000 Hz using a 16-channel telemetric transmission surface electromyograph (pocket EMG System, BTS, Milan, Italy). The lower and upper cut-off frequencies of the Hamming filter were 10 Hz and 400 Hz, respectively, while the common mode reaction ratio was 100 dB. Disposable Ag/AgCl bipolar surface electrodes, 1 cm in diameter, spaced 2 cm apart and greased with electro-conductor gel, were placed vertically on the left and right erector spinae muscles, approximately at L3, 2 cm from the midline.[1] The subjects were given standardized instructions to bend forward, let their arms and upper body "hang loose and dangle freely" and allow their backs to "relax completely." A metronome was used to regulate the speed of movement. A four-second forward bend was repeated five times so as to create a steady rhythm and fluidity of motion and as a "warm-up" exercise. Continuous sEMG readings were taken during test procedures, during which patients were asked to bend forward for four seconds, to maintain this bending position for four seconds and to stand up for four seconds, always using a metronome. For the purposes of this research, we decided to categorize the FR pattern as on/off. The rough sEMG signal was, therefore, rectified and visually inspected in order to detect the presence/absence of FR in each trial. Each patient performed five trials, each of which had to show continuous sEMG activity throughout the flexion movement for the FR to be considered absent. At each follow-up examination, the percentage of patients able ($FR_{[+]}$) or unable ($FR_{[-]}$) to achieve FR was calculated.

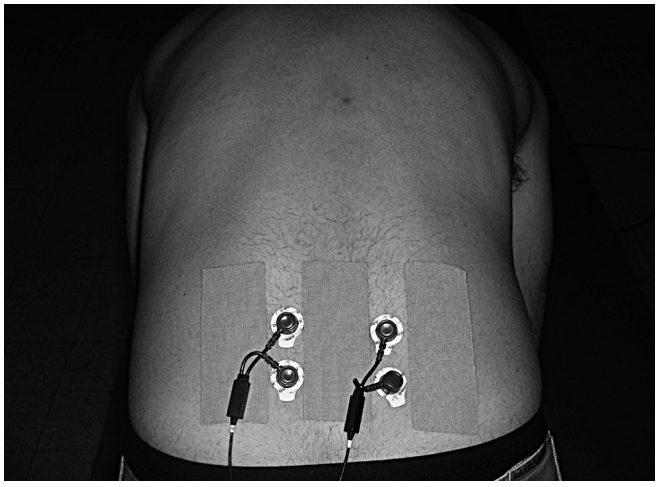

Figure 1.—Application of KT and of sEMG electrodes during forward bending.

Kinesio Taping

Three 20 cm x 5 cm stripes of Kinsiotape KT545 (Visiocare s.r.l., Vedano al Lambro, Monza-Brianza, Italy), a thin, cotton, porous, adhesive and latex-free elastic tape with a longitudinal elasticity of 40%, were applied over the lumbar spinal tract between the spinous process of the T12 and L5 vertebrae, which were manually identified by a physiotherapist. One stripe was placed over the midline, along a line corresponding to the spinous processes. Two stripes were placed on the right and left erector spinae muscles, 4 cm from the first stripe (Figure 1). Subjects were asked to bend forward during the taping procedure; no tension was used other than that required to cover the back in the bending position. The same trained therapist applied the tape to all the patients. The KT was changed every three days. As the KT is latex-free, it allows moisture and air to flow through it, thereby limiting skin irritation and allowing it to be worn comfortably for three-four consecutive days (even in the shower) without compromising its adhesive quality.

Therapeutic exercise

Patients underwent 30 minutes of therapeutic exercise, three times/week for four consecutive weeks. Each session was performed in groups of no more than five participants and directed by a senior physiotherapist, with over 10 years' experience in treating patients with CLBP. During sessions, patients were taught relaxation techniques as well as stretching and active exercises for the abdominal, lumbar and thoracic back extensors, psoas, ischiotibial and pelvic muscles. Although stretching and active exercises performed during the sessions were standard, the exercise intensity was adapted to the patients' ability. Patients were then encouraged to keep practicing at home after the end of the sessions.[16]

Study design

The study was divided in two phases: phase I consisted of an intra-subject pre-test/post-test procedure; in phase II we conducted a randomized, single-blinded controlled trial (Figure 2). After obtaining written informed consent from all the subjects, a clinical and instrumental evaluation was performed at the baseline (T0) to evaluate the inclusion and exclusion criteria. Patients who satisfied the inclusion criteria were then admitted to phase I (T1) and received KT.

In phase I, pain intensity was evaluated by means of a 10-cm horizontal VAS (0 cm: "no pain"; 10 cm: "worst pain I have ever had"). Subjects were asked to answer the question: "referring to the worst pain you have experienced in your life, what was the relative level of your back pain, when compared with pre-tape application?" by placing a mark somewhere along the line. FR was then recorded with the patient taped. Phase II started after removal of the tape.

In phase II, patients were randomized (T2) to either the KT and exercise group (KTEx-G), the KT-group (KT-G) or the exercise group (Ex-G) using a computer-generated allocation sequence. At the end of treatment (T3), all the patients underwent a clinical (VAS and RMDQ) and instrumental (FR) evaluation. All the data were collected and analyzed by an independent auditor who was not among the investigators who enrolled the participants and was blind to the treatments assigned. The procedures followed were approved by the Committee on Human Experimentation at our institution.

Statistical analysis

Statistical analysis was performed using the SSP 2.5 statistical package (Smith's Statistical Package, Gary Smith, Pomona College, Claremont, CA, USA). A paired t-test was performed to evaluate the effect

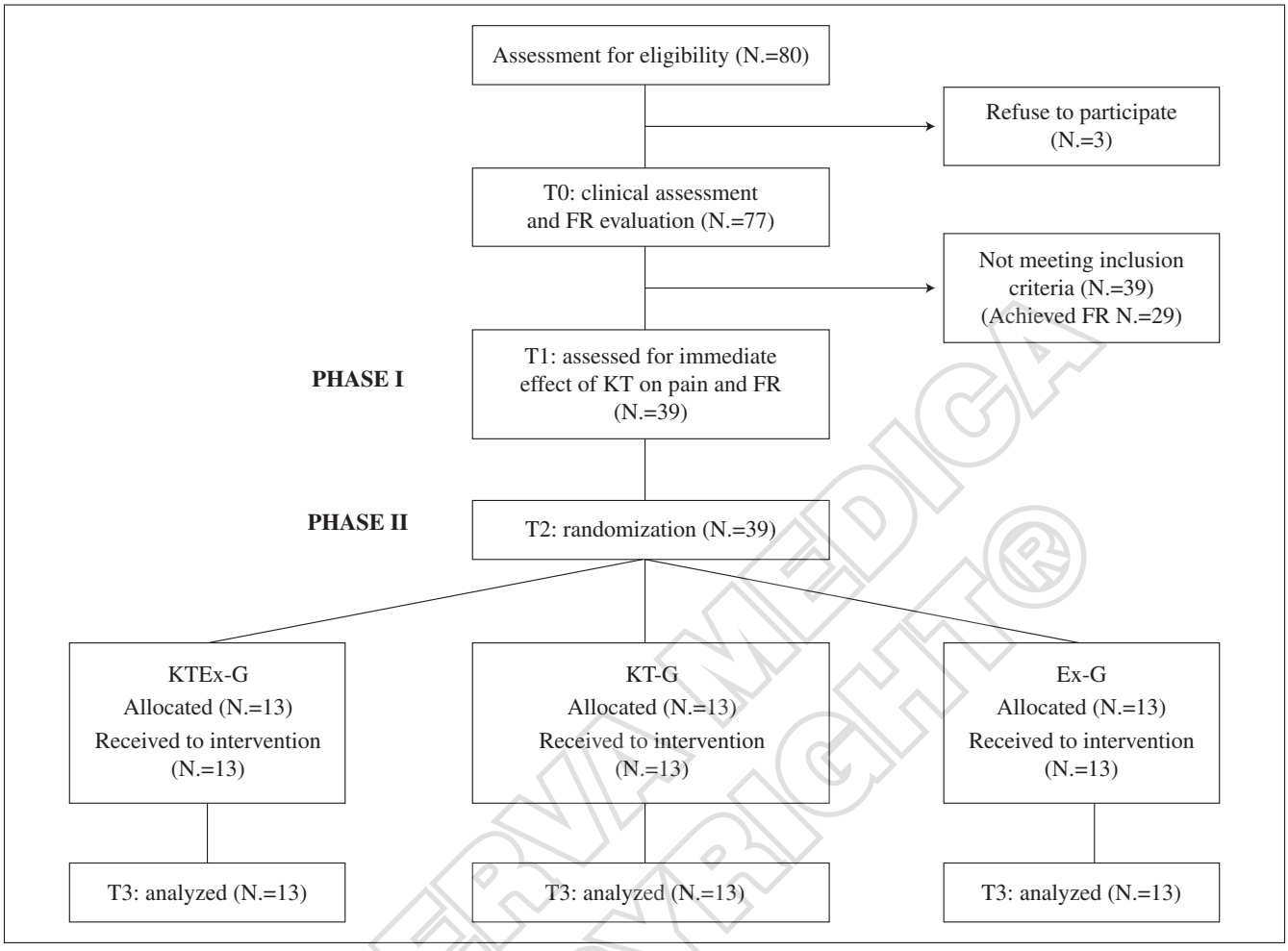

Figure 2.—Flow-chart diagram of the study.

of KT on pain in phase I. The influence of the clinical characteristics on responsiveness in terms of FR appearance and VAS reduction was calculated by means of an unpaired t-test or a Mann-Whitney U-Test for the continuous variables and a Fisher's Exact Test for the discrete variables. After randomization, normal distribution of age, VAS and RMDQ scores was verified in all three groups by means of a Shapiro-Wilkes test and parametric or non-parametric analysis of variance (ANOVA) was used, as appropriate, to determine differences between groups at T2. In phase II, we performed a two-way ANOVA to determine the effect of treatments on the VAS and RMDQ scores. A Tukey *post-hoc* test was used to assess significant differences between mean values when a significant main effect was found. The influence of the clinical characteristics on responsiveness in terms of FR appearance and VAS reduction was calculated by means of an Unpaired t-test or a Mann–Whitney U-Test for the continuous variables and a Fisher's Exact Test for the discrete variables. Statistical significance was set at $P<0.05$.

Results

Thirty-nine patients were enrolled for this research project. The demographic and clinical characteristics of our sample are outlined in Table I.

TABLE I.—*Demographic characteristics of our sample at baseline.*

Variable	KTEx-G		KT-G		Ex-G		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (years)	62.0	13.4	62.7	13.7	62.7	10.4	62.5	12.3
VAS (cm)	7.6	1.6	7.1	1.9	7.6	1.7	7.4	1.7
RMDQ	9.5	4.0	10.3	4.3	9.9	3.6	9.9	3.9
	N.	%	N.	%	N.	%	N.	%
Male	5	38.5	5	38.5	4	30.8	14	35.9
Pain characteristics								
Duration < 12 months	6	46.1	4	30.8	5	38.5	15	38.5
Widespread	9	69.2	11	84.6	8	61.5	28	71.8
Constant	4	30.8	6	46.1	8	61.5	18	46.1
Dull	7	53.8	7	53.8	8	61.5	22	56.4
Reduction with movement	4	30.8	5	38.5	4	30.8	13	33.3

KTEx-G: Kinesio Tape and Exercise group; KT-G: KinesioTape group; Ex-G: exercise group; VAS: Visual Analog Scale; RMDQ: Roland Morris Disability Questionnaire.

TABLE II.—*Mean (SD) values of VAS and RMDQ scores at baseline (T0) and at the end of the treatment (T3).*

	KTEx-G	KT-G	Ex-G	P[2]
VAS T0	7.6 (1.6)	7.1 (1.9)	7.6 (1.7)	NS
VAS T3	3.7 (2.5)	3.1 (2.8)	3.5 (2.4)	NS
P[1]	0.0001	0.0001	0.0001	
RMDQ T0	9.5 (4.0)	10.3 (4.3)	9.9 (3.6)	NS
RMDQ T3	7.3 (3.6)	9.5 (6.8)	5.4 (3.9)	NS
P[1]	NS	NS	0.01	

[1] P values for within group comparison; [2]P values for between group comparison.
VAS: Visual Analog Scale; RMDQ: Roland-Morris Disability Questionnaire; KTEx-G: Kinesio Tape and Exercise Group; KT-G: Kinesio Tape Group; Ex-G: Exercise Group; NS: not significant.

Phase I

A significant reduction in VAS was observed at T1, in both the whole sample (T0=7.4±1.7, T1=5.7±1.5; P<0.001) and in the $FR_{[+]}$ (T0=7.4±1.6, T1=6.1±1.3; P=0.001) and $FR_{[-]}$ (T0=7.5±1.8, T1=5.3±1.6; P<0.001) subgroups of patients. The VAS_R rate at T1 was 13/39 (33.3%). No significant effect on responsiveness in term of VAS reduction emerged for any of the variables analyzed. Normalized FR was observed in 17/39 patients (43.6%). A significant effect on responsiveness in terms of FR appearance was observed for age ($FR_{[+]}$:69.3±8.3, $FR_{[-]}$:57.2±12.4; P=0.001), RMDQ score ($FR_{[+]}$:11.4±2.9, $FR_{[-]}$:8.7±4.2; P=0.032) and gender ($FR_{[+]}$=10 males/7 females, $FR_{[-]}$=4 males/18 females; P=0.017), though not for pain (P=0.907).

Phase II

At T3, a significant reduction in the VAS scores from the baseline was observed in all three groups (Table II) (2-way ANOVA F=64.925; P<0.0001). The RMDQ scores were reduced in all three groups at T3 when compared with the baseline (Table II), though the difference was significant for the Ex-G alone (2-way ANOVA, F=6.031; P=0.01). Normalized FR at T3 was observed in 11/39 patients (28.2%). The $FR_{[+]}$ patients accounted for 30.8% of the patients in the KTEx-G, 23.1% in the KT-G and 30.8% in the Ex-G. A significant effect on responsiveness in terms of FR appearance was observed for age ($FR_{[+]}$:70.7±7.8, $FR_{[-]}$: 59.2±12.3; P=0.006) and gender ($FR_{[+]}$=7 males/4 females, $FR_{[-]}$=7 males/21 females; P=0.033). The number of patients classified as VAS_R at T3 was 29 (74.3%) in the whole sample, 9 (69.2%) in the KTEx-G, 10 (76.9%) in the KT-G and 10 (76.9%) in the Ex-G. The number of patients classified as RMDQ responders at T3 was 10 (25.6%) in the whole sample, 1 (7.7%) in the KTEx-G, 2 (15.4%) in the KT-G and 7 (53.8%) in the Ex-G. No significant effect on responsiveness in terms of VAS and RMDQ score reduction was observed for

any of the variables analyzed. No adverse events were recorded and every patient in all three groups completed the study.

Discussion

Immediate effects of KT on CLBP patients

In phase I of the research, we sought to demonstrate the immediate effect of KT application on pain and neuromuscular behavior in a group of CLBP patients who failed to achieve FR. Our results show that the mean VAS score significantly decreased after KT application; indeed, following KT therapy, one third of our patients were classified as VAS_R and displayed a mean VAS reduction of about 2 cm, which is considered to be the minimally clinically important VAS score change in CLBP.[17] Exactly how KT acts on musculoskeletal pain is not yet clear. Although the mechanism underlying the effect of KT is beyond the scope of this study, some hypotheses may be made in an attempt to understand how KT provides pain relief. Sensory modalities operate within interconnecting, intermodal and cross-modal networks.[18] A key question in recent years has been whether non-neuronal cells act as a key signaling pathway for sensory modalities by triggering adjacent nerve terminals or neuronal structures. Some studies have suggested that keratinocytes may represent the non-neuronal primary transducers of mechanical stimuli,[19, 20] probably through signal transduction cascade mechanisms such as intracellular Ca^{2+} fluxes to evoke a response in adjacent C-fibers. One appealing hypothesis is that the cutaneous stretch stimulation provided by KT may interfere with the transmission of mechanical and painful stimuli. Moreover, KT may provide afferent stimuli, thereby facilitating pain inhibitory mechanisms (gate control theory) and pain reduction.[21] In this regard, the use of three KT stripes in our protocol may have led to an increased involvement of cutaneous receptors. Interestingly, KT application led to the re-appearance of FR in 43.6% of the patients. We did not find any correlation between FR re-appearance and pain reduction, which is in keeping with previous studies that failed to find a relationship between pain state and EMG in persons with CLBP.[2, 22] Anomalous lumbar muscle activity is, however, significantly associated with pain-related fear in persons with CLBP.[23] Normalized FR may, therefore, result from correct sensory feedback in patients who receive KT, in whom fear of movement is consequently reduced and lumbar muscle function is improved. Sensory stimulation provided by KT may also represent a dynamic stabilization system of lumbar joints in a flexed position, which may help to reflexogenically inhibit muscle activity.[24, 25] Studies have shown that muscular fatigue may increase the EMG silence period of the erector spinae during a flexion-extension task and that deep cyclic lumbar flexion results in earlier cessation of EMG during flexion and delayed activation of trunk extensors during extension.[26, 27] Although we did not check the level of fatigue in our patients, no discomfort or adverse events suggesting the occurrence of fatigue were recorded in our sample. Obviously, since this phase consisted of a non-controlled trial, not all the effects observed can be attributed to the KT. Indeed, controlled trials are warranted to shed further light on the acute effects of KT on CLBP.

KT with or without therapeutic exercise in the short-term follow-up

The aim of phase II of our study was to evaluate the effect on pain and functionality of KT with or without therapeutic exercise over a four-week period. According to our results, patients in all three groups displayed a significant reduction in pain at T3, while only the exercise-alone group contemporarily displayed a decrease in pain-related disability. KT therefore reduced pain over a short follow-up period to a degree that was comparable to that observed with exercise. We speculate that taping may act as a continuous analgesic stimulus on back muscles ascribable to the afore-mentioned interaction between cutaneous receptors and pain transmission pathways.[19, 20] As our patients were invited to wear KT continuously for 4 weeks, reduced pain in daily living activities probably allowed them to move their backs more comfortably and correctly. At the end of the study period, FR reappeared in approximately one third of our sample. However, patients who performed therapeutic exercise displayed a higher rate of FR reappearance than those who did not. As FR was evaluated without KT at the end of the study period, the mechanisms underlying neuromuscular modulation are likely to be different from those hypothesized for the acute phase evaluation. Indeed,

the reappearance of FR in this phase may be considered to be a consequence of active restoration of lumbar muscle functional status. Interestingly, the groups that displayed the highest rate of FR reappearance also demonstrated better functional status results. In keeping with reports in the literature,[16, 28] pain-related disability in our study only changed in those patients who performed exercise. Although significance was attained by the patients in the Ex-G alone, those in the KTEx-G did display a mean RMDQ score reduction of 2.2 points, which is very close to what is considered to be the minimum clinically important change.[29] The genesis of disability in chronic conditions such as CLBP is, in fact, generally multifactorial [30, 31] and includes some aspects (*e.g.*, belief in recovery) that may be influenced by activity participation.[32] Bearing this in mind, although the application of KT cannot be considered as a substitute for therapeutic exercise in CLBP patients, it may be adopted as a additional, short-term strategy to reduce pain.

Limitations of the study

The main limitation of our study is the small sample size. Owing to the limited duration of the follow-up, we cannot determine whether KT definitely warrants inclusion in the treatment choices for CLBP patients. The positive effect of KT on acute pain, even in CLBP patients, suggests, however, that KT may be considered as an alternative method for controlling acute pain phases. Another limitation of our study is that our results were obtained in a particular CLBP sub-population, *i.e.*, those who could not achieve FR. Further studies are warranted to extend our results to all CLBP patients.

Conclusions

KT is promising as both immediate and short-term pain relief therapy when applied to CLBP patients. It rapidly reduces abnormal paraspinal sEMG activity and may, therefore, be effectively used to complement a physical rehabilitation program. Therapeutic exercise, either on its own or in association with KT, leads to a greater reduction in pain-related disability and to better muscle function restoration, as measured by FR.

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