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# Assessment of the effects of Kinesiotaping on musical motor performance in musicians suffering from focal hand dystonia: a pilot study

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**Abstract**

**Objective:** The aim of this study was to explore the immediate and short-term effects of a Correction Kinesiotaping intervention on fine motor control in musicians with focal hand dystonia.

**Design:** A single-blinded, single-arm repeated measures, pilot study.

**Setting:** Medical outpatient clinic.

**Subjects:** Seven musicians diagnosed with focal hand dystonia.

**Interventions:** Musicians performed musical exercises under the following conditions: without Kinesiotape (baseline), during a Correction Kinesiotaping intervention and immediately after tape removal (block 1) and during a Sham Kinesiotaping intervention and immediately after tape removal (block 2). Blocks were randomly presented across participants. A tailored Correction Kinesiotaping intervention on affected fingers was provided based on the dystonic pattern that each patient manifested while playing.

**Main measures:** Motor performance was video-documented and independent experts blindly assessed the general performance and fingers' posture on visual analogue scales. Also, musicians' self-reports of the musical abilities were evaluated. Finally, electromyographic activity and coactivation index of wrist antagonist muscles were analyzed.

**Results:** No significant differences in effects between Correction Kinesiotaping and Sham Kinesiotaping were reported by the experts, either for general performance ($P > 0.05$) or for fingers' posture ($P > 0.05$); any subtle benefits observed during Correction Kinesiotaping were lost after the tape was removed. Musicians estimated that Correction Kinesiotaping was ineffective in improving their musical abilities. Also, no significant changes with respect to the coactivation index ($P > 0.05$) were found among the conditions.

**Conclusion:** Correction Kinesiotaping intervention may not be useful to reduce dystonic patterns, nor to improve playing ability, in musicians with focal hand dystonia.

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## Introduction

Intensive training regimes can lead musicians to the manifestation of focal dystonia, a highly disabling movement disorder that often terminates their careers.[1] In most cases, musician's dystonia, also known as musician's cramp,[2] only appears focally in the context of instrument playing as a painless muscular incoordination of refined movements.[3]

In focal hand dystonia, the loss of coordination is characterized by involuntary curling of dystonic fingers, or extending of adjacent digits to compensate for such dysfunction, along with a prolonged co-contraction of both flexor and extensor muscles.[3,4]

To date, this condition is not easily treated and the most effective therapies often fail to restore fine motor control in musicians.[5–7] Given the limitations of the available treatment methods, the search for alternative interventions that are also connected to the musician's instrumental practice becomes compelling.[8–10]

Kinesiotaping is a kinesthetic method consisting of a tape having elastic properties and stretching capabilities.[11] In recent years, it has emerged in clinical practice as an interesting intervention for managing musculoskeletal conditions[12] and neurological disorders.[13] The inherent characteristics of the Kinesiotape, providing mechanical support without restricting movement, prompted us to investigate it as an alternative constraint-induced task-specific intervention against dystonic symptoms in affected musicians.

Therefore, we performed a pilot study to discover whether or not there is enough suggestion of benefit to warrant further research. For the primary outcome, we assessed whether the Correction Kinesiotaping intervention promoted improvements of the musical performance and the fingers' posture. As secondary outcome, we explored whether the effect was maintained shortly after removal of Kinesiotape.

## Methods

### Recruitment and selection of musicians

A single-blinded, single-arm repeated measures, pilot study was carried out. The target population was male musicians diagnosed with focal hand dystonia. Subjects were blinded to the purpose of the study and had no knowledge about the Kinesiotaping method. They were recruited from October to December 2016 from the outpatient clinic of the Institute of Music Physiology and Musicians' Medicine in Hannover where the study was also conducted.

All musicians had undergone a complete neurological examination and were diagnosed with primary focal hand dystonia by a neurologist (E.A.) specialized in movement disorders. A painless loss of fine motor coordination of finger movements arising in the task-specific context of playing the musical instrument was required to make the diagnosis. Loss of coordination consisted of the involuntary twisting of one or more fingers (dystonic fingers) and the uncontrolled extension outward of adjacent digits (compensatory fingers) in at least one of the two hands. The following exclusion criteria were applied: secondary dystonia, neuropsychiatric diseases and nerve compression syndromes.

Participants gave their informed consent to participate in the experiment, and each of them before being tested completed a questionnaire that documented age, handedness, the played instrument, the current professional situation and the history of any therapeutic measures used. All procedures were conducted according to the Declaration of Helsinki and were approved by the Institutional Ethics Committee (Area Vasta Centro AOU Careggi, Florence, Italy).

### Data collection—measurements

The main outcome was the assessment of the musician's motor performance when playing the instrument, based on estimates by independent experts, self-reports by the musician and electromyographic recordings.

*Expert video assessment.* Four professionally trained musicians, two of whom are experts in both music and movement disorders, who pursued a career in healthcare, evaluated motor skills of the affected musicians in a standardized video rating procedure.[14] Videos of the intervention and the post-intervention conditions (see section "The design") were all paired with the videos of the baseline condition and distributed to the raters in a randomized order under blinded labels. Raters were asked to evaluate, for each pair, differences between the video of the baseline condition and the video of the respective intervention and post-intervention conditions. Evaluations were based on the following two criteria: the "general performance" and the "fingers' posture." Assessments were performed on visual analogue scales,[15] which were constructed by horizontal lines (100 mm long). For the first criterion, the scale ranged from "strong deterioration of the performance" to "strong improvement of the performance" and for the second criterion, the scale ranged from "strongly deviating from natural posture" to "strongly resembling natural posture" (which means recommended playing posture). The exact middle of the visual analogue scales indicated no changes between the two videos (baseline versus experimental). Differences were expressed as percentages ranging from −100% to +100%.

*Musician self-assessment.* Musicians self-assessed their musical abilities by means of visual analogue scales (ranging from "strong deterioration" to "strong improvement"). Specifically, they were asked to assess their abilities in each respective intervention condition in comparison to their abilities during baseline. Self-evaluations were based on the following criteria: general performance, motor control (defined to musicians as the ability to manage fine motor control of fingers during playing), stiffness/relaxation, motor ability concerning musical rhythmic control (the ability to follow the specific rhythmical patterns of the different musical paradigms while playing with a metronome), intonation and expression. Differences were expressed as percentages ranging from −100% to +100%.

*Electromyography and coactivation index.* As in recent works investigating musicians with focal hand dystonia,[16,17] coactivation of wrist muscles was evaluated. The electromyographic activity of the flexor carpi radialis and the extensor carpi ulnaris was recorded by using four surface electrodes (Ag/AgCl electrodes, 3SG3-N; Multi Bio-Sensors Inc., El Paso, TX, USA). The ground electrode was placed on the left clavicle with the exception of the musician B (Table 1) who played violin (ground electrode placed on the right clavicle). In order to reduce impedance during the electromyography (EMG) recording, the skin was shaved and cleaned with a CV-Tronic electrode contact spray (Pharma-Depot GmbH, Versmold, Germany). An online analogue notch filter of 50 Hz was applied together with a high pass filter of 0.15 Hz and a low pass filter of 200 Hz (AC mode). Data were sampled at 1000 Hz, and the recording was performed by NeuroScan (NeuroScan, Inc, SynAmps, El Paso, TX, USA). All signals were Butterworth filtered offline with a cut-off frequency of 20 Hz and were then root mean squared. EMG data were normalized per subject based on the maximum voluntary contraction recorded at the end of the experiment. Maximum voluntary contraction was obtained by asking subjects to perform a maximum flexion and extension isometric force production against a stationary object for a ~5-second period. Data were filtered and root mean squared as above. The mean maximum voluntary contraction value of the central 66% of any amplitude larger than 15% of the maximum amplitude was averaged as the final maximum voluntary contraction of each participant.

The mean and peak activities of the wrist flexor and extensor muscles and the muscular coactivation index (the amount of co-contraction of the wrist flexor and extensor muscles calculated as[18] $CI=(2I_{ant} / I_{Total})\times 100\%$ with $I_{ant} = \int_{t1}^{t2} \mathrm{EMG}_{ext}(t)dt + \int_{t2}^{t3} \mathrm{EMG}_{flex}(t)dt$ and $I_{Total} = \int_{t1}^{t3}[\mathrm{EMG}_{agon} + \mathrm{EMG}_{ant}](t)dt)$ were computed for each musical exercise and then averaged per condition.

**Table 1.** Participants' characteristics.

| Musician(s) | A | B | C | D | E | F | G | All musicians with FHD (M ± SD) |
|---|---|---|---|---|---|---|---|---|
| Age (years) | 40 | 28 | 26 | 31 | 29 | 48 | 47 | $35.6 \pm 9.2$ |
| Handedness: right/left/ambidextrous | R | R | R | R | R | L | R | – |
| Instrument | Harpsichord | Violin | Piano | Piano | Piano | Guitar | Clarinet | – |
| Age started playing the instrument | 7 | 9 | 8 | 14 | 11 | 10 | 7 | $9.4 \pm 2.5$ |
| Years of experience | 33 | 19 | 18 | 17 | 18 | 38 | 40 | $26.1 \pm 10.4$ |
| Current occupation | Student | Professional | Student | Student | Student | Amateur | Teacher | – |
| Affected hand: right/left/both | L + R | L | R | R | R | L | L + R | – |
| Tested hand: right/left | L | L | R | R | R | L | R | – |
| Treated dystonic pattern[a] | **D2**, D3 | D1, D2, **D3** and **D4** | D2, **D3** and D4 | D2, **D3** and D4 | D2 and **D3** | D3, **D4** and **D5** | D4 and **D5** | – |
| Onset age of dystonic symptoms | 33 | 27 | 24 | 26 | 29 | 24 | 26 | $27 \pm 3.2$ |
| Duration of dystonia (years) | 7 | 1 | 2 | 5 | 1 | 24 | 21 | $8.7 \pm 9.7$ |
| Symptoms transferred to other activities | No | Yes | Yes | No | Yes | Yes | Yes | – |
| Self-rated playing ability after onset (%)[b] | 50 | 70 | 80 | 40 | 90 | 15 | 0 | $49.3 \pm 33.5$ |
| Self-rated playing ability today (%)[b] | 40 | 40 | 30 | 40 | 20 | 15 | 35 | $31.4 \pm 10.3$ |
| Severity of symptoms (%)[c] | 37 | 73 | 35 | 26 | 49 | 36 | 24 | $40 \pm 16.7$ |

FHD: focal hand dystonia; R: right; L: left; D1: thumb; D2: index finger; D3: middle finger; D4: ring finger; D5: little finger.
[a]Dystonic finger(s) is (are) in bold.
[b]Self-rated playing ability is judged subjectively by the musician: 100% = level before dystonia onset.
[c]The severity score is based on expert rating: 100% = healthy, 0% = playing impossible.

## The intervention

All participants received in two different time points a Correction and a Sham Kinesiotaping intervention. The application of the tape was conducted by the same investigator to ensure consistency throughout the study.[19] A standard black Kinesio® Tex Tape (Kinesio Holding Company, Albuquerque, NM, USA) was used for both experimental Correction and control Sham Kinesiotaping interventions.

*Correction Kinesiotaping intervention.* The intervention was applied based on previous medical taping examples.[11] The application of this technique aimed to reduce the severity of dystonic pattern in the musician during musical performance by restricting the altered movement of the fingers mechanically. The taped fingers were different for each musician depending on the dystonic patterns triggered while playing.

Correction Kinesiotaping application on a dystonic finger (Supplemental Figure S1) aimed to normalize its uncontrolled flexion motion into the palm. Tape strip, 2.5 cm wide, was applied on the dorsal surface of the finger while keeping it in full extension. The tape was first anchored with no tension slightly below the distal interphalangeal joint by splitting the distal part of the strip in two smaller strips of 1.25 cm length wrapping them around the finger. Then, Kinesiotape was fully stretched to the middle of the strip and stably anchored over the metacarpal and the wrist areas without tension. Subsequently, the strip was applied directly on the dorsal surface of the dystonic finger with inward pressure. Correction Kinesiotaping application on a compensatory finger aimed to limit the uncontrolled extending movement during playing. Tape strip, 2.5 cm wide, was applied on the palmar surface of the finger, while subject keeping it curved into the palm. The tape was first anchored to the distal interphalangeal joint, fully stretched and anchored over the palm of the hand until the wrist without tension. Afterward, the strip was placed on the palmar surface of the compensatory finger.

*Sham (control) Kinesiotaping intervention.* For the control intervention (Supplemental Figure S1), new strips of Kinesiotape were used and applied on the same fingers on which the Correction Kinesiotaping technique was tested. All strips were applied with no tension while keeping the finger in a natural semiflexed, relaxed posture. The procedure of application on individually affected finger was similar to that adopted in the experimental intervention, though all elements attempting to correct dystonic pattern during musical performance mechanically were removed. Also, in order to minimize the extra-proprioceptive input provided by Kinesiotape during the finger flexion and extension movements, due to the stimulation of cutaneous mechanoreceptors via stretching/deformation of skin,[19–22] each strip was split into two smaller ones which were applied on the lateral and medial surfaces of whole finger (Supplemental Figure S1). Our Sham Kinesiotaping intervention, though covering the same amount of skin as in the Correction Kinesiotaping, prevented the extrastimulation of mechanoreceptors on the dorsal and palmar surfaces of the fingers, regions subjected to greater stretching/deformation of skin while the finger flexion and extension movements occur.

## The design

At the beginning of the session, each musician was informed that he would undergo two different types of taping interventions, each one potentially effective. Furthermore, two examples of the preprepared tape strips that would have been applied during the Correction or the Sham Kinesiotaping intervention were demonstrated to the participant. The great similarity of the interventions prevented the musicians from recognizing which tape was the effective or the sham one. This information was revealed to them at the end of the experimental session.

After the installation of the surface EMG electrodes, the musician spent 5 minutes warming up in which he was free to play a repertoire of his choice (Figure 1).[16] In the subsequent 5 minutes, the experimenter showed the performance task to be completed and gave participant some time to familiarize with it. The performance task consisted of four music diatonic exercises tailored to each individual based on the instrument played (Supplemental

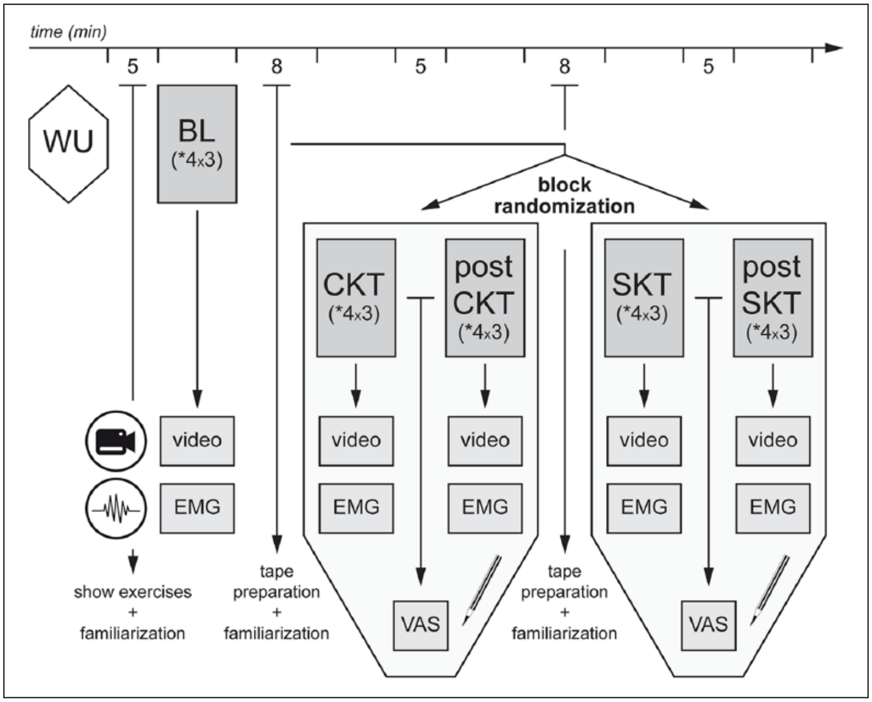


**Figure 1.** The experimental design.
BL: baseline condition; CKT: Correction Kinesiotaping condition; EMG: electromyography; SKT: Sham Kinesiotaping condition; VAS: visual analogue scale; WU: warm up.
*In every condition, the musician performed four simple music diatonic exercises, each one repeated three times.

material). All exercises were performed with a metronome cueing. Tempi were adjusted, at the beginning of the experimental procedure, to each individual based on the severity of symptoms.[10,23] Also, the order of musical exercises was randomized among participants.

After familiarization, musician executed the performance task in order to complete the first (baseline) condition. Since the possibility existed that the Kinesiotaping interventions might have interfered with the baseline due to carryover effects,[24] this condition was performed first.

Once baseline measurements were completed, two different blocks were performed; one block included the Correction and the post-Correction Kinesiotaping conditions, whereas the other block included the Sham and the post-Sham Kinesiotaping conditions. The two blocks were randomized across participants to avoid possible carryover effects (Figure 1). Before the beginning of the Correction and the Sham Kinesiotaping conditions, the musician's hand was taped and some time was given to participant to get acquainted with the Kinesiotape while playing the musical exercises. After each intervention condition (Correction or Sham Kinesiotaping) was completed, the tape was removed and musician executed again the performance task in order to complete the respective post-intervention conditions as well (post-Correction or post-Sham Kinesiotaping).

The performance task and the surface EMG activity were recorded during all five conditions (Figure 1). Also, the musician was asked to assess his musical abilities immediately after the Correction and the Sham Kinesiotaping conditions (Figure 1), before removing the tape from his hand (for more details about the assessment see section "Musician self-assessment").

## Data analysis

A non-parametric analysis was conducted due to the small number of participants ($n=7$) and the fact that 13 out of 46 variables were not normally distributed (Shapiro test, $P<0.05$). For comparisons between two or more conditions, the Wilcoxon signed-rank test and Friedman's test were used, respectively. In cases of multiple comparisons, Bonferroni adjustments were applied. Correlations between variables of interest were assessed using Spearman's rho, $r_s$ (two-tailed). Two-Way Random Consistency intraclass correlation coefficients (ICCs) were estimated in order to assess the inter-rater reliability.[25] ICC was estimated for the assessment of the criteria "general performance" and "fingers' posture," respectively. Significance level was set to alpha = 0.05. Effect size was estimated using Pearson's correlation coefficient $r$ for single comparisons and Kendall's $W$ (coefficient of concordance) for multiple comparisons. Data analysis was conducted first across the overall group and second for each participant separately. Statistical analysis was performed in IBM SPSS Statistics software package (version 24) and R (version 3.4.2).

## Results

All demographic, music- and disorder-related characteristics of the musicians are presented in Table 1. In the experts' video analysis, raters were asked to assess two different criteria: the general performance and the fingers' posture (Supplemental Figure S2 and Table 2). Friedman's test showed a significant effect among the four conditions for both criteria, respectively. Post hoc pairwise comparisons for the criterion general performance indicated a significant difference only between Sham and post-Sham Kinesiotaping conditions (Supplemental Figure S2a). Post hoc pairwise comparisons for the criterion fingers' posture indicated significant differences between Correction and post-Correction, Sham and post-Sham, Correction and post-Sham and Sham and post-Correction Kinesiotaping conditions. (Supplemental Figure S2b). All statistical details are presented in Table 2.

**Table 2.** Expert video assessment of general performance and fingers' posture changes relative to the baseline and pairwise comparisons.

| Criteria | Conditions | | | | | | | Pairwise comparisons | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CKT_{bl}$ Median (min, max, IQR) | Post-$CKT_{bl}$ Median (min, max, IQR) | $SKT_{bl}$ Median (min, max, IQR) | Post-$SKT_{bl}$ Median (min, max, IQR) | $\chi^2_{(3)}$ | $P$* | W | $CKT_{bl}$ vs $SKT_{bl}$ Mdn diff. ($P$, $r$) | Post-$CKT_{bl}$ vs post-$SKT_{bl}$ Mdn diff. ($P$, $r$) | $CKT_{bl}$ vs post-$CKT_{bl}$ Mdn diff. ($P$, $r$) | $SKT_{bl}$ vs post-$SKT_{bl}$ Mdn diff. ($P$, $r$) | $CKT_{bl}$ vs post-$SKT_{bl}$ Mdn diff. ($P$, $r$) | $SKT_{bl}$ vs post-$CKT_{bl}$ Mdn diff. ($P$, $r$) |
| General performance[a] | 14.50 (7, 25, 14) | −7.93 (−13, 15, 26) | 23.28 (−5, 29, 29) | −4.85 (−8, 10, 17) | 10.7 | 0.013 | 0.510 | −8.78 (>0.05, –) | −3.08 (>0.05, –) | 22.43 (>0.05, –) | 28.13 (0.043, 0.6)** | 19.35 (>0.05, –) | 31.21 (>0.05, –) |
| Fingers' posture[b] | 17.44 (12, 31, 15) | −4.74 (−10, 15, 18) | 9.75 (6, 40, 29) | −3.48 (−6, 5, 7) | 16.9 | 0.001 | 0.804 | 7.69 (>0.05, –) | −1.26 (>0.05, –) | 22.18 (0.011, 0.6)** | 13.23 (0.043, 0.6)** | 20.92 (0.023, 0.6)** | 14.49 (0.023, 0.6)** |

$CKT_{bl}$: Correction Kinesiotaping relative to the baseline; IQR: interquartile range; $SKT_{bl}$: Sham Kinesiotaping relative to the baseline; Mdn diff.: Median difference; max: maximum; min: minimum; W: Kendall's W (coefficient of concordance) for multiple comparisons; r: estimation of the effect size with the Pearson's correlation coefficient.

[a]Assessment: −100% = strong deterioration of the performance to 100% = strong improvement of the performance.

[b]Assessment: −100% = strongly deviating from natural posture to 100% = strongly resembling natural posture.

*Level of significance for the effect among the different conditions was accepted after a Bonferroni correction at $P<0.05/2=0.025$.

**Level of significance for the post hoc pairwise comparisons was accepted after Bonferroni adjustment.

**Table 3.** Musician self-assessment of the following criteria between the $CKT_{bl}$ and the $SKT_{bl}$ conditions.

| Criteria[a] | $CKT_{bl}$ Median (min, max, IQR) | $SKT_{bl}$ Median (min, max, IQR) | *Z* | *P* (two-tailed) |
|---|---|---|---|---|
| General performance | 9.38 (0, 63, 29) | 4.17 (−57, 49, 7) | −1.153 | 0.249 |
| Motor control | 10.42 (0, 52, 22) | 0 (−68, 49, 33) | −1.521 | 0.128 |
| More stiff/relax of the: | | | | |
| Fingers | 6.25 (−6, 48, 27) | 4.17 (−70, 46, 13) | −0.507 | 0.612 |
| Hand | 0 (0, 28, 8) | 2.08 (−69, 47, 6) | 0 | 1 |
| Forearm | 2.08 (−25, 27, 6) | 0 (−43, 47, 31) | −0.535 | 0.593 |
| Improvements/deteriorations concerning: | | | | |
| Rhythmic control | 0 (−25, 71, 41) | 4.17 (−55, 31, 86) | −1.014 | 0.31 |
| Intonation | 0 (−38, 27, 22) | 0 (−44, 35, 0) | −0.365 | 0.715 |
| Expression | 0 (−29, 52, 53) | 0 (−19, 35, 11) | −0.365 | 0.715 |
| Playing ability (%)[b] | 40 (20, 97, 55) | 40 (10, 100, 35) | −1.461 | 0.144 |

$CKT_{bl}$: self-assessment of the musical performance during the Correction Kinesiotaping intervention relative to the baseline; IQR: interquartile range; $SKT_{bl}$: self-assessment of the musical performance during the Sham Kinesiotaping intervention relative to the baseline; max: maximum; min: minimum.
[a]Assessment: –100% = strong deterioration to 100% = strong improvement.
[b]The playing ability during the CKT and the SKT conditions was also estimated in comparison to the variable "Self-rated playing ability today (%)" (Table 1), 100% = level before onset dystonia. The significant threshold is set at 0.05.

Correlations between the assessments of general performance and fingers' posture for the different conditions are shown in Supplemental Table S1. Spearman' s rho indicated a significant positive correlation for both the Correction and the post-Correction Kinesiotaping conditions. No significant correlations were found for Sham or post-Sham Kinesiotaping conditions.

Moreover, ICC for the assessment of the general performance and the fingers' posture, respectively, were conducted in order to estimate the inter-rater reliability for the different conditions (Supplemental Table S2).

In addition, musicians estimated no beneficial effects in improving their general playing ability when the Correction Kinesiotaping intervention was applied. Comparisons of effects between the Correction and the Sham Kinesiotaping interventions on the different criteria appear in Table 3.

Finally, the mean activity, the peak activity and the muscular co-contraction of the wrist flexor and extensor muscles were evaluated. For all muscular parameters no differences among conditions were found and no further post hoc analyses were conducted (Table 4).

Individual values of all the different assessments of Correction and Sham Kinesiotaping conditions are also presented in Supplemental Table S3. In general, all assessments are aligned with the abovementioned group analysis. Only some slight contradictions between objective and subjective assessments were observed for two of the patients (musicians C and D).

## Discussion

This study showed that the Correction Kinesiotaping intervention did not improve the musical motor performance in musicians with focal hand dystonia. No differences in effects between Correction Kinesiotaping and Sham Kinesiotaping were reported by the external experts, either for the "general performance" or for the "fingers' posture" criteria. Also, musicians self-estimated that Correction Kinesiotaping was ineffective in improving their general playing ability. In some musicians, however, and independent from the type of intervention, Kinesiotaping was subjectively estimated to improve refined motor control during playing. These individual subjective improvements though

**Table 4.** Mean activity, peak activity and co-contraction changes relative to the baseline.

| Electromyography (%MVC)[a] | Baseline median (min, max, IQR) | Conditions | | | | | |
|---|---|---|---|---|---|---|---|
| | | $CKT_{bl}$ median (min, max, IQR) | Post-$CKT_{bl}$ median (min, max, IQR) | $SKT_{bl}$ median (min, max, IQR) | Post-$SKT_{bl}$ median (min, max, IQR) | $\chi^2_{(3)}$ | *P* |
| Mean activity[b] of: | | | | | | | |
| Wrist flexor | 0.13 (0.03, 0.19, 0.09) | 0.04 (0.02, 0.16, 0.01) | 0.04 (0.00, 0.14, 0.02) | 0.03 (0.00, 0.10, 0.06) | 0.06 (0.01, 0.09, 0.06) | 2.4 | 0.495 |
| Wrist extensor | 0.24 (0.16, 0.44, 0.21) | 0.09 (0.05, 0.40, 0.13) | 0.07 (−0.02, 0.46, 0.11) | 0.09 (0.02, 0.21, 0.13) | 0.13 (0.01, 0.25, 0.10) | 0.4 | 0.934 |
| Peak activity[b] of: | | | | | | | |
| Wrist flexor | 0.52 (0.21, 0.92, 0.29) | 0.21 (0.07, 0.79, 0.21) | 0.18 (0.03, 0.80, 0.17) | 0.23 (0.03, 0.37, 0.22) | 0.16 (0.01, 0.34, 0.28) | 0.9 | 0.815 |
| Wrist extensor | 1.34 (0.68, 2.13, 0.87) | 0.42 (0.12, 1.32, 0.52) | 0.42 (−0.09, 1.42, 0.45) | 0.51 (−0.13, 0.72, 0.52) | 0.31 (−0.13, 0.72, 0.52) | 0.9 | 0.815 |
| Co-contraction[c] | 1.46 (0.89, 1.78, 0.54) | −0.22 (−0.50, 0.34, 0.74) | −0.15 (−0.36, 0.63, 0.20) | −0.05 (−0.47, 0.36, 0.54) | −0.24 (−0.37, 0.22, 0.37) | 1.1 | 0.774 |

IQR: interquartile range; $CKT_{bl}$: Correction Kinesiotaping relative to the baseline; $SKT_{bl}$: Sham Kinesiotaping relative to the baseline; max: maximum; min: minimum.
[a]Values are normalized based on the maximum voluntary contraction (%MVC).
[b]Positive or negative values indicate an increase or a decrease, respectively, of the mean/peak activities in comparison to the baseline.
[c]Positive or negative values indicate an increase or a decrease, respectively, of co-contraction of wrist antagonist muscles relative to the baseline. The significant threshold is set at 0.05. Bonferroni adjustments are used.

were not supported by changes in muscular activity and co-contraction between flexor and extensor wrist muscles. Finally, no changes relative to the baseline were observed in all measurements evaluating performance after removal of the Correction Kinesiotaping.

So far, the most effective available treatment for dystonic symptoms in musicians with dystonia is the injection of a neurotoxin, the botulinum toxin,[26] whose effectiveness was proved to be maintained even after more than a decade of continuous therapy.[27]

However, besides the reported efficacy of the botulinum toxin, patients tend to abandon the therapy, largely because the treatment fails to meet their expectations or needs.[26,28] In addition, the use of botulinum toxin in professional musicians can be limited by the narrow therapeutic window of the neurotoxin, especially in small muscles that should preserve muscular force for playing, for example, the left finger flexors in cello players.[7]

Moreover, in agreement with findings indicating that behavioral factors underlie musician's dystonia, alternative effective treatments that target mainly the restoration of fine motor control have also been proposed.[8–10,29] Examples of successful behavioral therapies for the treatment of musician's dystonia are pedagogical "retraining" protocols focusing on the re-programming of motor abilities[8] or the "sensory motor retuning" consisting of an intensive task-specific constraint-induced therapy in which splints are used to prevent compensatory movements, while the dystonic fingers intensely practice.[10]

In comparison to the available treatments, the corrective Kinesiotaping technique explored in our pilot study as alternative constraint-induced intervention failed as a whole to improve playing ability in dystonic musicians.

The videotaped blind rating analysis indicated some slight improvements of the criteria investigated when musicians applied either the experimental Correction Kinesiotaping intervention or the Sham Kinesiotaping intervention. However, due to the very low inter-rater reliability in the Correction Kinesiotaping condition, data should be presented with caution. It seems that raters tended to evaluate both Correction and Sham conditions more positively than the baseline. The visibility of the applied Kinesiotape on the hand could have created some bias. The small number of participants tested in this study could also explain the low degree of agreement among raters in estimating the differences between the baseline and the Correction or the post-Sham Kinesiotaping conditions, respectively. It was previously suggested that a large number of individuals could likely expand inter-rater reliability.[30]

Also, musicians' self-assessments indicated that the Correction Kinesiotaping intervention was ineffective in improving their general playing ability. However, at single-case level some individual improvements were reported (Supplemental Table S3). For instance, patient C estimated improvements during the Correction Kinesiotaping condition, whereas patient D experienced an advantage in playing his instrument in both the intervention conditions, with stronger improvements while wearing Sham Kinesiotape.

Self-perceived improvements of the musical performance in these two cases, which were not supported by the objective assessments, could be linked to the occurrence of the "sensory trick," a phenomenon shown to reduce motor symptoms in some musicians with focal dystonia.[23] Although the physiology of sensory tricks is not well understood, it is suggested that changes in sensory feedback given by an external somatosensory stimulus may adjust or compensate for abnormalities in sensorimotor processing[31–33] providing, in turn, a temporary relief of the motor symptoms.[34] Therefore, we speculate that the additional stimulus provided by Kinesiotape may have been sufficient to improve temporary sensorimotor integration in musicians C and D, augmenting their fine motor control during playing. This hypothesis could also be supported by a study revealing the ameliorative effect of the Kinesiotaping treatment on pain and sensory functions in patients with cervical dystonia and focal hand dystonia (writer's cramp).[13] A limitation of such study was the lack of a kinematic quantitative assessment of motor deficit before and after the intervention. However, recent studies showed the efficacy of Kinesiotape in improving the accuracy of a rhythmic motor performance when it was applied on upper limbs in healthy subjects.[20–22]

In addition, it is possible to note that the improvements reported by musicians C and D during the Kinesiotaping interventions were positively overestimated as compared to experts' assessments (Supplemental Table S3). Hence, another conceivable explanation for the self-report improvements in these patients could also be the unrealistic estimation or the impaired capacity of dystonic musicians to self-evaluate changes in their own motor performance. This assumption has been already documented in a previous study on patients with musician's dystonia reporting that only 40% out of entire sample estimating subjective motor improvements showed real objective regain of their motor playing ability.[8]

Moreover, patients' expectations have been proposed to play an important role in the "placebo effect."[35] Recent studies investigated the "true" effect of Kinesiotaping using a deception experimental design[36,37] and concluded that placebo effects may be associated with the positive outcomes shown in previous works. Since in our experiment at the start of the session each musician was informed that he would undergo two different types of taping interventions, each one potentially effective, a further possible explanation of this positive outcome could be the occurrence of a placebo effect caused by the patients' expectations from Kinesiotaping.

Furthermore, the muscular (mean and peak) activity and the co-contraction of the wrist flexor and extensor muscles showed no visible differences among conditions. Muscle coactivation, a critical motor control strategy to implement joint stability and movement accuracy,[38,39] was suggested to be increased in patients with focal hand dystonia.[4,40] In our sample, though some individual improvements were estimated in two of seven patients during Kinesiotaping conditions (based mainly on the self-reports), the co-contraction activity of wrist antagonist muscles revealed no changes at all. The objective assessments are in support of the insufficient effect of the Correction Kinesiotaping intervention. However, it should be noted that co-contraction of wrist antagonist muscles might not be specific only to dystonia since it can occur in any voluntary activity that requires a stiff hand position.[41] Co-contraction could be instead a general compensatory process similar to that found in healthy subjects, as suggested by Farmer et al.[40] Similarly, Ioannou et al.[17] showed that dystonic musicians had a reduced ability to perform musical scales compared to healthy pianists, though no changes in muscular co-contractions were found between the two groups. Subsequently, our EMG results might be regarded also as a consequence of a ceiling effect of the coactivation index because of the very low degree of co-contraction of the wrist flexor and extensor muscles during performance in all conditions (the median co-contraction value in the baseline was 1.45% of the maximum voluntary contraction; Table 4), which diminished our chance to observe visible changes in the coactivation index during and after the intervention.

Finally, a secondary aim of the study was to explore whether possible beneficial tendencies of Correction Kinesiotaping could last after tape removal. In general, our results suggest that benefits offered by Correction Kinesiotaping, if any, were lost when the bandage was removed.

A few limitations concerning the current investigation should be addressed. First, the number of participants remains relatively small. Second, a comparison with a control group was not planned for this study. Future non-pilot studies should preferably include a group of healthy musicians as well. Third, though the randomization was used, each patient underwent both the Correction and the Sham Kinesiotaping interventions. Future studies could apply the experimental and the sham Kinesiotape in two different groups of dystonic patients, respectively. Fourth, the reason for selecting videotaped blind rating analysis was due to the lack of a standardized and objective assessment tool able to evaluate heterogeneous groups of musicians (mix of instruments). However, because of the fact that in some video conditions the musician's hand was presented with the Kinesiotape applied and in some video conditions without, a Pygmalion effect seemed to affect raters' perception by causing an overestimation of the conditions where the tape was presented.[42] The only available tool to measure objectively motor performance in dystonic musicians is the MIDI-based scale analysis which so far is available exclusively for pianists.[43] Therefore, we recommend that future studies should include only pianists. This will ensure higher reliability of the motor assessment methods.

In conclusion, this study examined for the first time the effect of Kinesiotape as a potential treatment tool against musician's hand dystonia. Results offer insufficient evidence of any effect of the Correction Kinesiotaping intervention to warrant further investigations. Future studies exploring the effect of Kinesiotape in patients with focal dystonia should rather focus on possible long-term effects. Perhaps, the lesson from this study is that we have to consider whether any positive outcome by the Kinesiotaping method could potentially emerge as a release of a sensory trick. To explore further this observation, in relation also to a better understanding of sensorimotor integration in dystonia, future studies should be designed.

**Clinical messages**

- A Correction Kinesiotaping intervention may not be useful in reducing dystonic patterns, nor in improving playing ability.

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## Author contributions

R.B. made substantial contributions to the conception and design of the research project, data acquisition, interpretation of data, writing of the first draft of manuscript, revising it critically for important intellectual content and final approval of the version to be published. C.I.I. made substantial contributions to the design of the research project, data analysis, interpretation of data, writing of the first draft of manuscript, revising it critically for important intellectual content and final approval of the version to be published. D.M. made substantial contributions to the conception of the research project, concept and art work for figures of manuscript, revising it critically for important intellectual content and final approval of the version to be published. E.A. made substantial contributions to the organization of research project, interpretation of data, revising it critically for important intellectual content and final approval of the version to be published.

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