Acute Effect of Inhibitory Kinesio-tape of the Upper Trapezius on Lower Trapezius Muscle Excitation in Healthy Shoulders

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METHODS

Design

A repeated-measures, crossover design was used to determine the acute effect of KT applied to the UT on muscle excitation of the LT. Participants were asked to perform a repeated arm elevation task during three different taping conditions: no KT, experimental KT and sham KT. During each taping condition, participants performed a bilateral repeated arm elevation task during two loading conditions: no load and loaded with 2.3 kilograms. All six conditions were tested during one visit, with the no load condition preceding the loaded condition for each taping condition. A baseline trial (no KT; N-KT) was performed first, followed by both an experimental-KT (E-KT) and sham-KT (S-KT) condition. The order of the E-KT and S-KT conditions were randomized and counterbalanced (Research Randomizer v4.0, Social Psychology Network, Lancaster, PA, United States) (Figure 1). Testing for each tape condition during both the no load and loaded conditions lasted approximately 10-minutes, requiring a total of 45-minutes of testing time per participant including screening, EMG set-up and clean-up. No wash-out period was given between S-KT and E-KT taping conditions; the first tape condition was removed upon completion of the arm elevation task and the second tape condition was applied immediately after. KT was applied to the UT and muscle excitation (EMG amplitude) was measured in the LT using the same 32-electrode high-density surface electromyography (HD-sEMG) grid during the repeated arm elevation task. All data were collected in a laboratory setting at the University of Manitoba.

Participants

Twenty-two right-handed individuals between the ages of 18 and 60 with no current shoulder pain or pathology participated in the study (24 ±3 years). Participants were recruited via convenience sampling of the University of Manitoba Faculty of Kinesiology and Recreation Management student and staff population, and the general population in the surrounding community. A potential participant was excluded if they had a recent history (<6 months) of injury or orthopedic disorder of the shoulder, upper back or neck (e.g. rotator cuff tears, disc pathologies, etc.), neurological or musculoskeletal disorder (e.g. epilepsy, multiple sclerosis, etc.), current pain in the shoulder, upper back or neck and previous allergies or skin sensitivity to tape or adhesives. Participants were not screened for scapular dyskinesis. All experimental procedures were approved by the University of Manitoba's Education/ Nursing Research Ethics Board in the spirit of the Helsinki Declaration. Participants received complete written and verbal details of the experimental procedures and potential risks involved prior to providing informed consent. This clinical trial was registered retroactively in the U.S. National Library of Medicine ClinicalTrials.gov database: NCT04711447.

<u>Kinesio-tape (KT)</u>

Each participant completed an arm elevation task under three taping conditions: first with no tape (N-KT), then with experimental-KT (E-KT) and sham-KT (S-KT) in random order (Figure 1). The KT was applied by one of two Certified Athletic Therapists, each with training and over four years of experience with KT. The therapists were the only individuals aware of the taping condition as the researchers and participants were blinded. The skin over the right UT was cleaned with an alcohol swab prior to the placement of the KT. The KT (2" Leukotape K, BSN Medical, Hamburg, Germany) was applied to dry skin over the UT approximately parallel to its fibers beginning proximally, 5-7.5cm lateral to C3 spinous process, and finishing distally at the right acromion process (Figure 2A). The S-KT was applied with no tension (0% stretch) and the participant was instructed to look straight ahead to maintain a neutral neck and shoulder position (Zanca et al 2016). The E-KT was applied using an inhibitory taping technique previously described for the gastrocnemius (Davison et al. 2016), modified for the UT. Specifically, the UT was placed in a stretched position by instructing the participant to bring their chin to chest and rotate to their left shoulder. The proximal tape anchor was applied lateral to C3 with no tension, stretched to ~125% tension from original length, and laid onto the skin over the right UT. The distal tape anchor was then applied to the UT bony attachment at the acromion with zero tension (Davison et al. 2016). The Certified Athletic Therapists used their clinical judgement to subjectively measure ~125% tension, first by stretching the tape to 200% of its original length, reducing to 150%, and then to ~125%. The participant was then instructed to relax their head back into neutral once the KT was applied.

High-density surface electromyography (HD-sEMG)

Muscle excitation of the LT was measured during the arm elevation task of all three taping conditions using HD-sEMG. Prior to electrode placement, the skin was shaved (if necessary), cleaned with an abrasive paste (Nuprep, Weaver and Company, Aurora, Colorado, USA), and wiped with an isopropyl alcohol swab (70%). One semi-disposable 32-electrode grid (GR10MM08804, OT Bioelettronica, Torino, Italy) arranged in eight rows and four columns (gold coated, interelectrode distance, 10mm) was applied to the LT approximately halfway between T12 and the middle of the spine of the right scapula (Figure 2B). Electrode rows were placed approximately parallel to the LT's fiber direction.

The electrode grid was covered with a disposable adhesive foam matrix (KITAD4x8NM6, OT Bioelettronica, Torino, Italy) filled with conductive paste (Ten20, Weaver and Company, Aurora, Colorado, USA) and secured to the participant's skin for the duration of the visit with tape (Hypafix, BSN Medical, Hamburg, Germany). Ground electrodes were placed at the participant's wrist and C7 spinous process (Figure 2B).

Repeated arm elevation task

For each tape and load condition participants performed ten repetitions of standing bilateral arm abduction in the frontal plane beginning with their arm resting by their side (Figure 2C). Participants were instructed to raise their arms bilaterally to full shoulder abduction (180°) while keeping their elbow fully extended and forearm supinated (Figure 2D). Participants were familiarized with performing the arm elevation task immediately prior to performing the N-KT condition (Figure 1). A research assistant performed the arm elevation task at a rate of 40 beats per minute while participants were asked to follow a metronome and mimic the researcher. Each repetition lasted for a total of three beats, or ~3 seconds, beginning with their arms by their sides. The participant's arm ascended into abduction where the first beat occurred at maximal abduction, followed by descending back to starting position where the second beat occurred. The third beat acted as a rest beat before beginning the next repetition and continued this for a total of 10 repetitions. An external load of 2.3kg was utilized to increase muscular demand while still allowing the participant to perform the required volume of arm abductions. Clinically, a load of 2.3kg is used to exacerbate scapular dyskinesia when present (McClure et al 2009).

Data processing and extraction

HD-sEMG was recorded and processed using a Dell laptop (Latitutide 5500, Dell Canada, Toronto, ON, Canada). HD-sEMG signals were recorded in monopolar and converted to digital using a 16-bit multichannel amplifier (Quattrocento, 400-channel EMG amplifier, OT Biolelettronica, Torino, Italy; Common Mode Rejection Ratio > 95 dB). Signals were amplified (150V/V), sampled at 2048 Hz and bandpass filtered (10–500 Hz; -3 dB bandwidth). Data were further filtered using a 30 Hz highpass filter (2nd order Butterworth) to minimize electrocardiographic noise (Drake and Callaghan 2006). Single differential spatial filtering of adjacent monopolar signals within each row were calculated using OT Biolab + (OT Bioelettronica, Torino, Italy), resulting in three differential values for each row of the grid. Root mean square (RMS) was then calculated for each differential signal and averaged within rows to determine individual row RMS (e.g. row 1 RMS). Shifts in the distribution of EMG amplitude within the LT were considered to be indicated by statistically significant differences in row RMS between conditions. Whole-muscle LT RMS was calculated by averaging RMS across all 8 rows. Data were exported from OT BioLab+ (version 1.3.2, OT Bioelettronica, Torino, Italy) as a .csv file in 0.1 second epochs. RMS for each contraction was defined as the maximum RMS value achieved over a 1.5 second interval within each arm elevation repetition. The data from the 1st and 10th repetition were removed and mean of RMS EMG values from 2nd through 9th repetitions was calculated for statistical analysis.

<u>Statistical Analysis</u>

Inferential statistical analysis was performed using SPSS (Version 25; IBM Corp, Armonk, New York, USA). A two-way repeated measures ANOVA was used to determine if differences in whole-muscle LT excitation existed between taping and loading conditions. One-way repeated measures ANOVAs were also conducted to determine the effect of tape condition during the loaded condition on the spatial distribution of excitation for each row.

Normality for all procedures was assessed by Shapiro-Wilk's test of normality. Data were considered normally distributed if $p > .05$. Sphericity was assessed by Mauchly's test of sphericity. The assumption of sphericity was met if $p \leq .05$. For the two-way repeated measures ANOVA, outliers were considered to be studentized residuals greater than ±3 standard deviations. For the one-way repeated measures ANOVAs, outliers were determined by boxplot inspection, with values greater than 1.5 box-lengths from the box considered outliers. Alpha was set at $p \leq .05$ for all statistical tests. A small effect size is considered $n^2 = 0.01$, a medium effect size is considered $n^2 = 0.06$, and a large is considered $n^2 = 0.14$ (Cohen 1988).

RESULTS

For comparison of whole-muscle LT excitation, analysis of studentized residuals indicated that the data were normally distributed, as assessed by Shapiro-Wilk's test of normality ($p > .05$). No outliers were present. One participant was removed from the analysis due to technical error. Another was removed due to incomplete data, resulting in $N = 20$ participants for the two-way ANOVA, and $N = 21$ for the one-way ANOVAs. Mauchly's test of sphericity was not met, $X^2(2) = 7.329$, $p = .026$. As such, a Greenhouse-Geisser correction was applied. There was no statistically significant interaction between tape and loading condition, $F(1.499, 28.476) = 1.368$, $p = .266$ (Figure 3). There was, however, a main effect for the loaded condition on whole-muscle LT excitation with a very large effect size, $F(1, 19) = 38.038$, $p < .001$, partial $\eta^2 = .667$. Across all tape conditions, whole-muscle LT RMS in the loaded condition (M =.055 V, SE = .005) was significantly higher than the no-load condition (M = .038 V, SE = .004), with a mean difference of .017 V (95% CI, .011 to .023). There was no main effect of tape condition on whole-muscle LT RMS, $F(1.967, 37.38) = 0.370$, $p = .690$.

For comparison of spatial distribution of excitation, data for row one baseline, row five baseline, row five sham, and row six KT were not normally distributed as assessed by Shapiro-Wilk test of normality ($p < .05$). Mauchly's test of sphericity was not met $p < .05$ in row one in the loaded E-KT condition, as such, a Greenhouse-Geisser correction was applied. Row one contained four outliers (load; N-KT, E-KT and S-KT) and row eight contained three outliers (load; E-KT and S-KT) as assessed by boxplot inspection. Statistical analysis was conducted with and without the inclusion of outliers, and it was determined that the outliers did not affect the results. As such, outliers were not removed from analyses. There were no significant differences across tape conditions in grid row RMS (Table 1).

Achieved power for the whole muscle excitation load main effect was estimated post-hoc using G*Power (3.1.9.3, Faul, Erdfelder, Lang, & Buchner, 2007). Given an analyzed sample of $N = 20$, with a =0.05 and an effect size of 0.667 (partial $\eta 2$), the achieved power (1 - β- error probability) is > 0.99.