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Efficacy of 3 therapeutic taping configurations for children with brachial plexus birth palsy

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ABSTRACT

Study Design: Cross-sectional clinical measurement study.
Introduction: Scapular winging is a frequent complaint among children with brachial plexus birth palsy (BPBP). Therapeutic taping for scapular stabilization has been reported to decrease scapular winging.
Purpose of the Study: This study aimed to determine which therapeutic taping construct was most effective for children with BPBP.
Methods: Twenty-eight children with BPBP participated in motion capture assessment with 4 taping conditions: (1) no tape, (2) facilitation of rhomboid major and rhomboid minor, (3) facilitation of middle and lower trapezius, and (4) facilitation of rhomboid major, rhomboid minor, and middle and lower trapezius (combination of both 2 and 3, referred to as combined taping). The participants held their arms in 4 positions: (1) neutral with arms by their sides, (2) hand to mouth, (3) hand to belly, and (4) maximum crossbody adduction (CBA). The scapulothoracic, glenohumeral and humerothoracic (HT) joint angles and joint angular displacements were compared using multivariate analyses of variance with Bonferroni corrections.
Results: Scapular winging was significantly decreased in both the trapezius and combined taping conditions in all positions compared with no tape. Rhomboids taping had no effect. Combined taping reduced HT CBA in the CBA position.
Conclusions: Rhomboid taping cannot be recommended for treatment of children with BPBP. Both trapezius and combined taping approaches reduced scapular winging, but HT CBA was limited with combined taping. Therefore, therapeutic taping of middle and lower trapezius was the most effective configuration for scapular stabilization in children with BPBP. Resting posture improved, but performance of the positions was not significantly improved.
Level of Evidence: Level II.

Introduction

Typical shoulder motion requires coordinated control of scapulothoracic (ST) and glenohumeral (GH) motion, referred to as scapulohumeral rhythm.[1-3] Altered ST function (ie, scapular dyskinesis) has been associated with a variety of shoulder pathologies,[4-7] including brachial plexus birth palsy (BPBP).[8-12]

Children with BPBP demonstrate complete spontaneous recovery approximately two-thirds of the time,[13,14] whereas roughly 1 in every 1000 live births results in BPBP with sustained deficits.[15] The long-term effects of BPBP include decreased limb length[16-18] and girth,[16,17] abnormal scapular morphology,[8,19-25] GH dysplasia,[19-22,24-30] muscle weakness, and reduced range of motion.[16,22,31-34] A common complaint among children with BPBP and their caretakers is the appearance and frustration associated with

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scapular winging (protrusion of the scapula away from the chest wall).[9,11,35-37] Scapular winging is a visible indication of the child's injury and also causes difficulty maintaining clothing, such as a bra strap or bathing suit top for female patients. The etiology of scapular winging in the BPBP population is unclear as the long thoracic and dorsal scapular nerves are expected to be intact in most children with C5-C6 or C5-C7 injuries.[9,11,35,38] Postganglionic upper trunk injuries typically occur distal to the long thoracic and dorsal scapular nerve branches. Preganglionic avulsion injuries of C5 and C6 are uncommon in children with C5-C6 and C5-C7 injuries.[39-42] Scapular winging in the BPBP population is thought to serve as a compensatory mechanism for lack of GH motion, including decreased GH crossbody adduction (CBA),[11] and it is typically managed conservatively.

Nonsurgical treatments for scapular winging include passive and active range of motion exercises, recreational activities that involve use of the upper extremities, electrical stimulation, and therapeutic taping.[43] The goals of these interventions are to strengthen muscles, alleviate muscle tightness, and prevent joint contracture formation or progression. Although these interventions are frequently used, objective evidence demonstrating their efficacy is lacking.

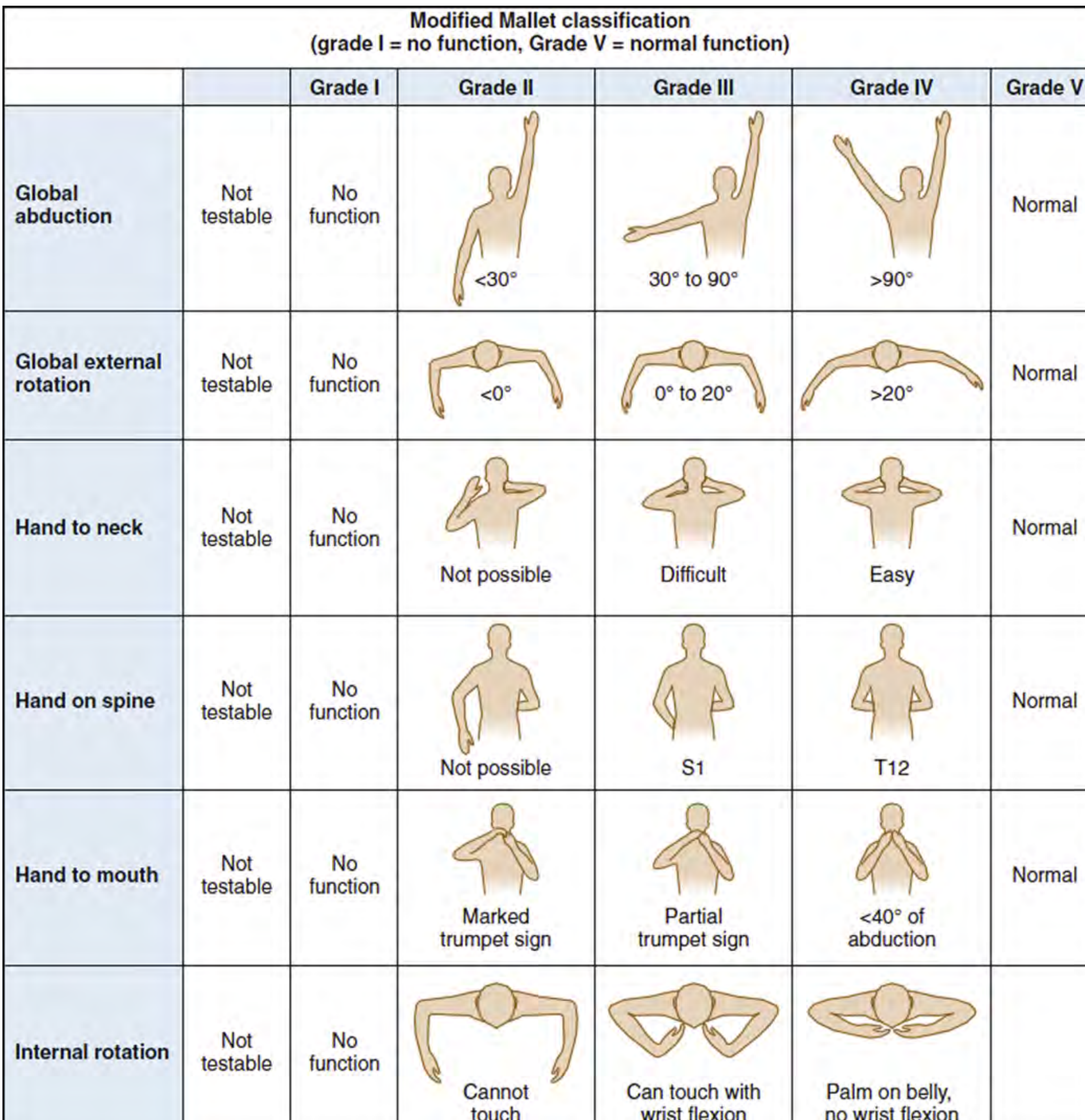

Fig. 1. The modified mallet classification is a functional assessment used to evaluate overall upper extremity performance in children with brachial plexus birth palsy.[29]

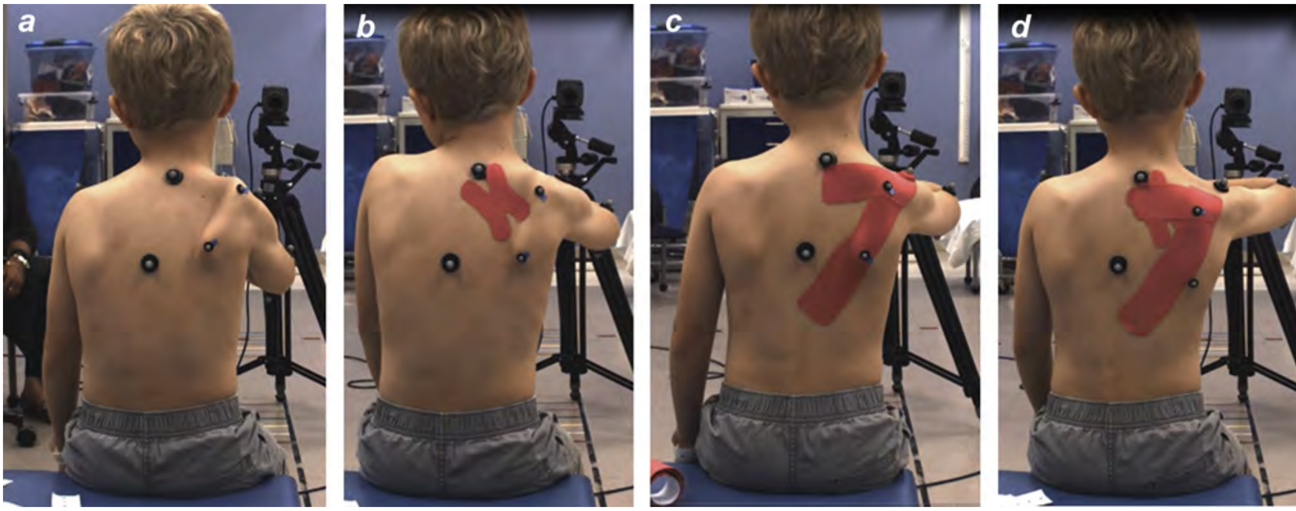

Fig. 2. Marker positions are shown in the hand to mouth position for (**A**) no tape, (**B**) rhomboid major and rhomboid minor facilitation tape, (**C**) middle and lower trapezius facilitation tape, and (**D**) combined rhomboids and trapezius facilitation tape.

Previous studies investigating the effect of therapeutic taping of the scapula are inconsistent.[12,44-55] In addition, they encompass different types of tape and tape application methodology.[49] One randomized trial comparing therapeutic Kinesio taping with sham taping (Kinesio tape applied without any tension) in young adults with rotator cuff tendonitis and/or impingement found no significant differences in goniometer-measured scapular range of motion during active abduction, forward flexion, or elevation in the scapular plane.[52] However, other previous reports identified changes in scapular kinematics,[12,46,53] muscle activity,[46,48] and proprioception.[48] According to the manufacturer, Kinesio tape encourages muscle strengthening, decreases muscle fatigue by providing support, and provides proprioceptive input to improve awareness.[56] Kinesio tape may also promote functional improvement by maintaining optimal alignment for movement.[56] Application of Kinesio tape may alter translation of subcutaneous tissue, fascia, and muscle, which could affect muscle function.[57]

In the BPBP population, Walsh[54] reported a case study of a child with BPBP who demonstrated improved GH congruity and scapular orientation, based on radiographic evaluation, after a therapeutic taping intervention with Kinesio tape. However, radiographic imaging is not frequently used to evaluate GH joint morphology as unossified articular structures cannot be visualized; magnetic resonance imaging is typically the imaging modality of choice.[21,22,25,30] Another study used motion capture technology to assess 26 children with BPBP before and after applying Kinesio tape to facilitate middle and lower trapezius.[12] ST, GH, and humerothoracic (HT) joint orientations and angular displacements were measured at rest and in each of the modified mallet positions, a set of 6 tasks used to assess upper extremity function in the pediatric BPBP population (Fig. 1).[12,58] The therapeutic taping for middle and lower trapezius resulted in clinically small but statistically significant decreases in scapular winging in 6 of 7 tested positions.[12] In addition, GH CBA and/or internal rotation increased significantly in

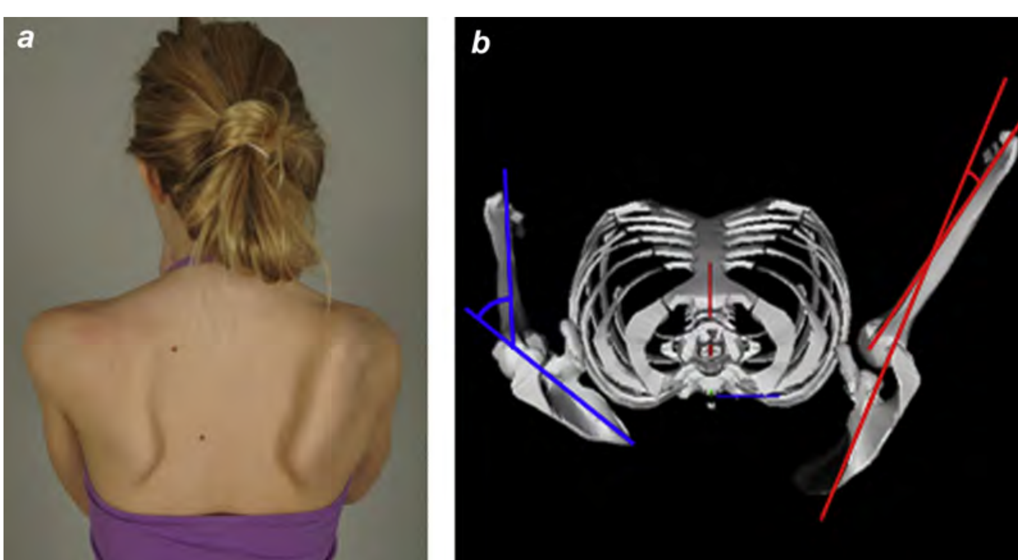

Fig. 3. (**A**) Clinical photo: a patient with brachial plexus birth palsy performing the hand to mouth position bilaterally. The right side is affected. The same patient's motion capture data from a superior view is shown in (**B**) illustrating the lack of glenohumeral (GH) crossbody adduction (CBA) on the affected right side (the GH joint is actually demonstrating counterproductive GH CBA as shown by the red angle) and associated increased scapular winging compared with the contralateral side. The left unaffected GH joint is oriented in GH CBA, which is depicted by the blue angle. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

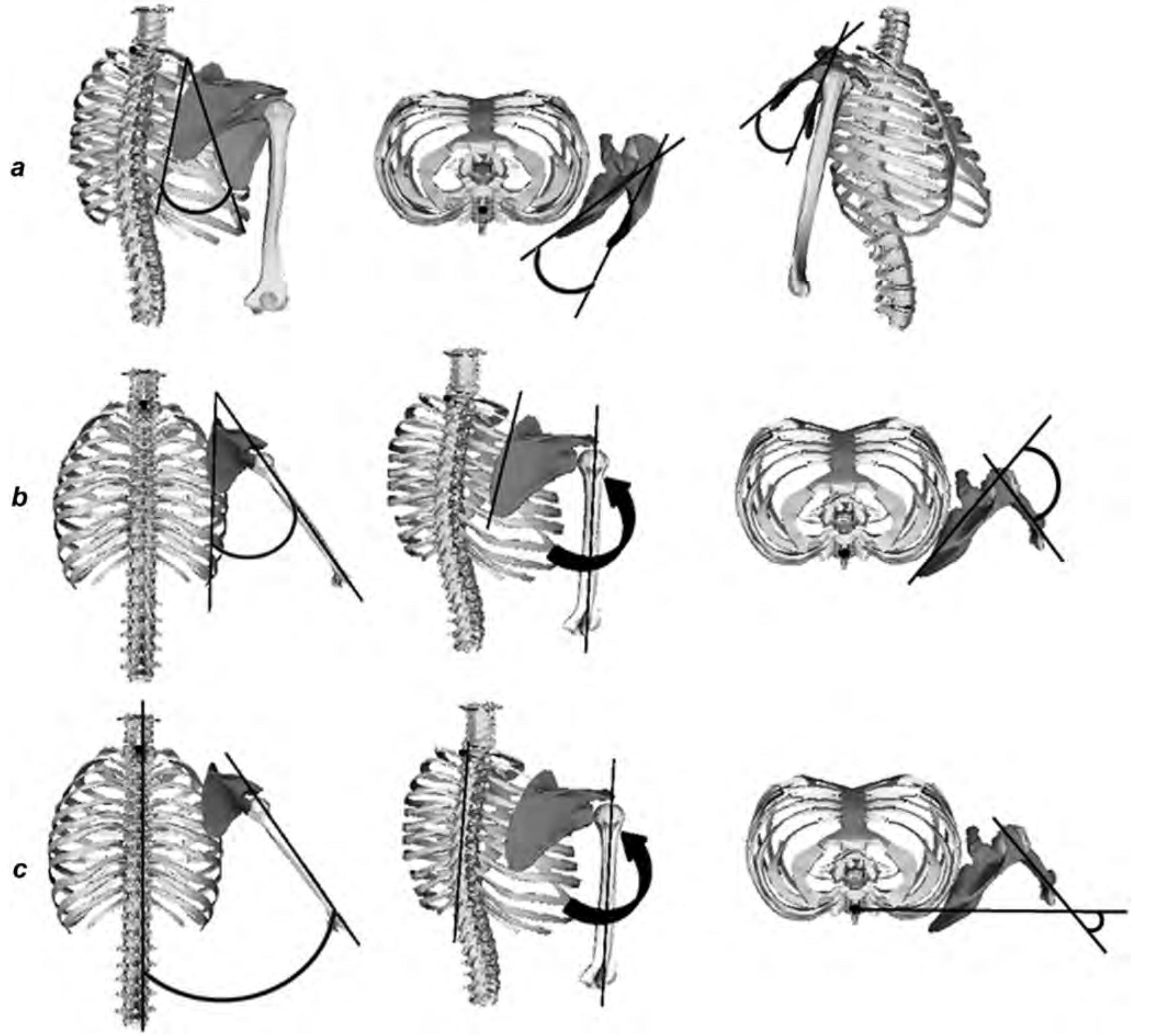

Fig. 4. (**A**) The scapulothoracic joint angles from left to right are upward/downward rotation, internal/external rotation (scapular winging is numerically represented by increased scapulothoracic internal rotation), and anterior/posterior tilt. (**B**) The glenohumeral and (**C**) humerothoracic joint angles from left to right are elevation, internal/external rotation, and crossbody adduction/abduction.

4 positions. However, the only change in HT function was a statistically significant decrease of 3° of external rotation in the external rotation position.[12]

Although the long-term outcome of therapeutic Kinesio taping remains unknown, the results of this prior study suggested that consistent, although clinically small, changes in ST and GH joint functions could be achieved with therapeutic taping to facilitate middle and lower trapezius.[12] Demonstrating that a baseline change in ST and GH joint resting orientations can be achieved with therapeutic tape and largely maintained during upper extremity motion was the first step in objectively assessing the efficacy of therapeutic taping for scapular stabilization in children with BPBP. The next step is to determine the most effective taping construct, which is the premise of the current work. This information will help inform treatment for children with BPBP. The objective of this study is to quantitatively measure the changes in ST, GH, and HT joint orientations and angular displacements with 3 different therapeutic taping constructs for scapular stabilization in children with BPBP: (1) facilitation of rhomboid major and minor, (2) facilitation of middle and lower trapezius, and (3) combined facilitation of rhomboid major and minor as well as middle and lower trapezius. We hypothesized that a combined taping approach to facilitate multiple scapular stabilizing muscles would have the greatest impact due to an additive effect of the 2 individual taping approaches.

Materials and methods

Participants

Twenty-eight children with BPBP participated in this study. Informed consent was obtained in accordance with the institution's human subjects review board. Each child was assessed by a licensed

Table 1
Each participant's diagnosis (Erb's palsy, extended Erb's palsy, or total plexus palsy), age, and relevant surgical history are shown

Diagnosis	Patient	Age	Primary nerve surgery	Shoulder tendon transfer	Arthroscopic release	Humeral osteotomy
Erbs	1	12				
	2	10			X	
	3	13			X	
	4	13				X
	5	14				
	6	12		X		
	7	7		X		
	8	15				
	9	5				
	10	7				
	11	13				X
	12	10			X	X
	13	5				
	14	7		X		
	15	14			X	
	16	13				
	17	7		X		
	18	9				
	19	6				
	20	5				
Extended	21	8		X	X	X
	22	11		X	X	
	23	6	X	X		
	24	7			X	
	25	17	X	X		
	26	7	X			
	27	15		X		X
Total	28	8			X	

Shoulder tendon transfers were either teres major or both teres major and latissimus dorsi.

and registered occupational therapist experienced in pediatric occupational therapy to confirm suitability for scapular stabilization with therapeutic taping. The occupational therapy assessment consisted of a subjective evaluation of increased scapular winging (compared with the contralateral limb) that was readily improved with manual manipulation. Because one method of therapeutic taping was intended to facilitate the trapezius muscle, children who had spinal accessory nerve transfers or lower trapezius tendon transfers were excluded due to potential compromise of trapezius function. In addition, open wounds or poor skin integrity were considered contraindications for therapeutic taping and, thus, children with these conditions were excluded from the study. The final exclusion criterion was excessive soft tissue that would potentially hinder palpation and placement of anatomic markers on the scapula.

Data collection

Retroreflective markers were applied to the following anatomic landmarks: spinous processes of T2 and T8, sternal notch, acromion process, trigonum spinae (intersection of the scapular spine and medial border of the scapula), inferior angle of the scapula, and medial and lateral epicondyles of the humerus. Three-dimensional coordinates of these markers were recorded with a 10 camera motion capture system (Vicon, Centennial, CO; Motion Analysis Corporation, Santa Rosa, CA). Participants were seated and asked to hold their arms by their sides in a neutral resting position with their hands hanging free. The trigonum spinae and inferior angle scapular markers were palpated and placed with the participants in this position. The participants were then asked to hold their arms in the following positions: hand to mouth (Fig. 2A), internal rotation, and CBA. The scapular markers on the trigonum spinae and inferior angle were repalpated and placed while the children held their arms in each position to ensure accurate measurement of ST orientations. The hand-to-mouth and internal rotation (hand to belly)—modified mallet positions (Fig. 1) were chosen because they demonstrated the greatest decreases in scapular winging with therapeutic taping in a previous study that assessed each of the modified mallet positions.[12] Maximal CBA (Fig. 3) was selected because lack of GH CBA is associated with scapular winging.[11]

Motion capture data were collected for 4 taping conditions: (1) no tape, (2) facilitation of rhomboid major and rhomboid minor, (3) facilitation of middle and lower trapezius, and (4) facilitation of rhomboid major, rhomboid minor, and middle and lower trapezius (combination of both 2 and 3, referred to as combined taping). For the taping of rhomboids, participants were asked to place their hands on the opposite shoulders while the scapular motion was manually augmented by the therapist during application of the tape with paper-off tension (Fig. 2B). For the trapezius taping, participants retracted their scapulae toward the spine, and the therapist manually augmented this scapular motion during application of the tape with paper-off tension (Fig. 2C). In the combined taping condition, the rhomboids tape was applied first, and then, the trapezius tape was applied following the same steps described previously (Fig. 2D). The order of taping conditions was rotated for each participant to limit the impact of a potential learning effect associated with performing the positions multiple times.

Data analysis

Custom-written software (LabVIEW 2014; National Instruments, Austin, TX) was used for data analysis. Thoracic, scapular, and humeral coordinate systems were generated so that the axes aligned with those recommended by the International Society of Biomechanics.[59] ST, GH, and HT joint angles were calculated for each trial. ST joint angles (Fig. 4A) were computed using an order-independent helical angle approach.[10,12] The GH and HT joint angles (Figs. 4B and 4C) were calculated using an order-independent modified globe method.[11,12,60,61] The modification used for this study was calculating internal and/or external rotation as the degrees of rotation about the long axis of the humerus between the neutral trial and each of the tested positions. The International Society of Biomechanics recommends using Euler angles to determine ST, GH, and HT joint angles[59]; however, the joint angles calculated with Euler angles best match clinical observations when the first rotation occurs about the axis of greatest motion and the last rotation occurs about the long axis of the distal segment. Due to this constraint, a single Euler sequence would not produce clinically applicable results for the different positions tested in this study. Therefore, the order-independent helical and globe methods were selected. In addition, the ST, GH, and HT joint angular displacements were calculated from the neutral trial to each of the other tested positions in each taping condition.

Statistical analysis

The ST, GH, and HT joint orientations were compared in each of the taping conditions using a 1-way repeated-measure multivariate analyses of variance with SPSS statistical software (SPSS, version 23; IBM, Armonk, NY). The factor levels consisted of taping condition (no tape, rhomboids tape, middle and lower trapezius tape, and combined tape), and the dependent variables were each of the 3 joint angles (rotation about each anatomic axis). A Bonferroni correction was used to account for examining multiple joints, which brought the alpha level to 0.017. After a significant Wilk's lambda ($\alpha = 0.017$), univariate analyses of variance (ANOVAs) were performed to determine which joint orientations reached significance. The dependent variables were assessed for skewness, kurtosis, and sphericity. A few

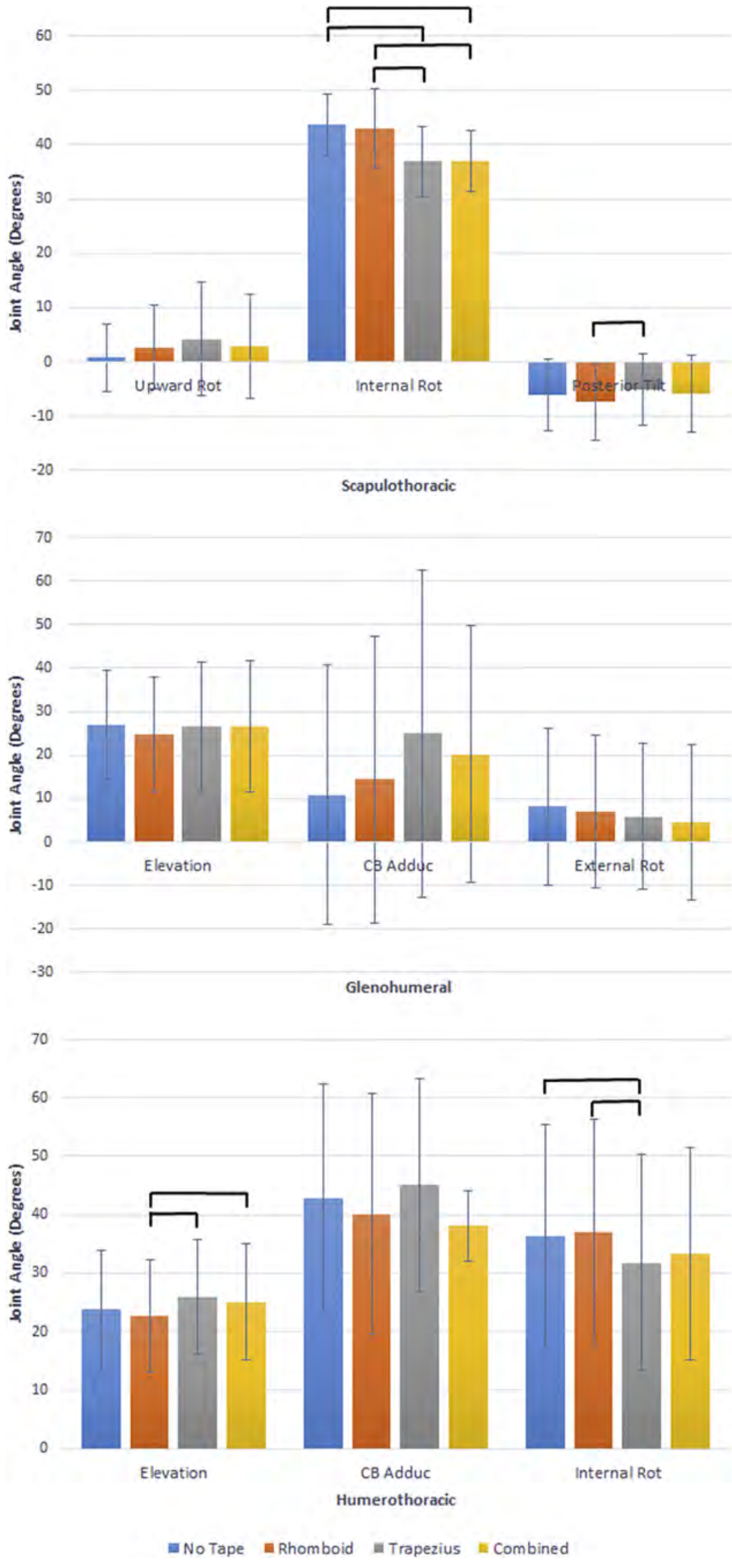

Fig. 5. The scapulothoracic, glenohumeral, and humerothoracic joint angles are shown for the neutral position. Each taping condition is represented by a separate bar. The significantly different joint angles are indicated by the black brackets. All *P* values for the multivariate analyses of variance and univariate analyses of variance were less than .017. The *P* values for the post hoc, Bonferroni, and pairwise comparisons (shown by the black brackets) were all less than .05. CB Adduc = crossbody adduction.

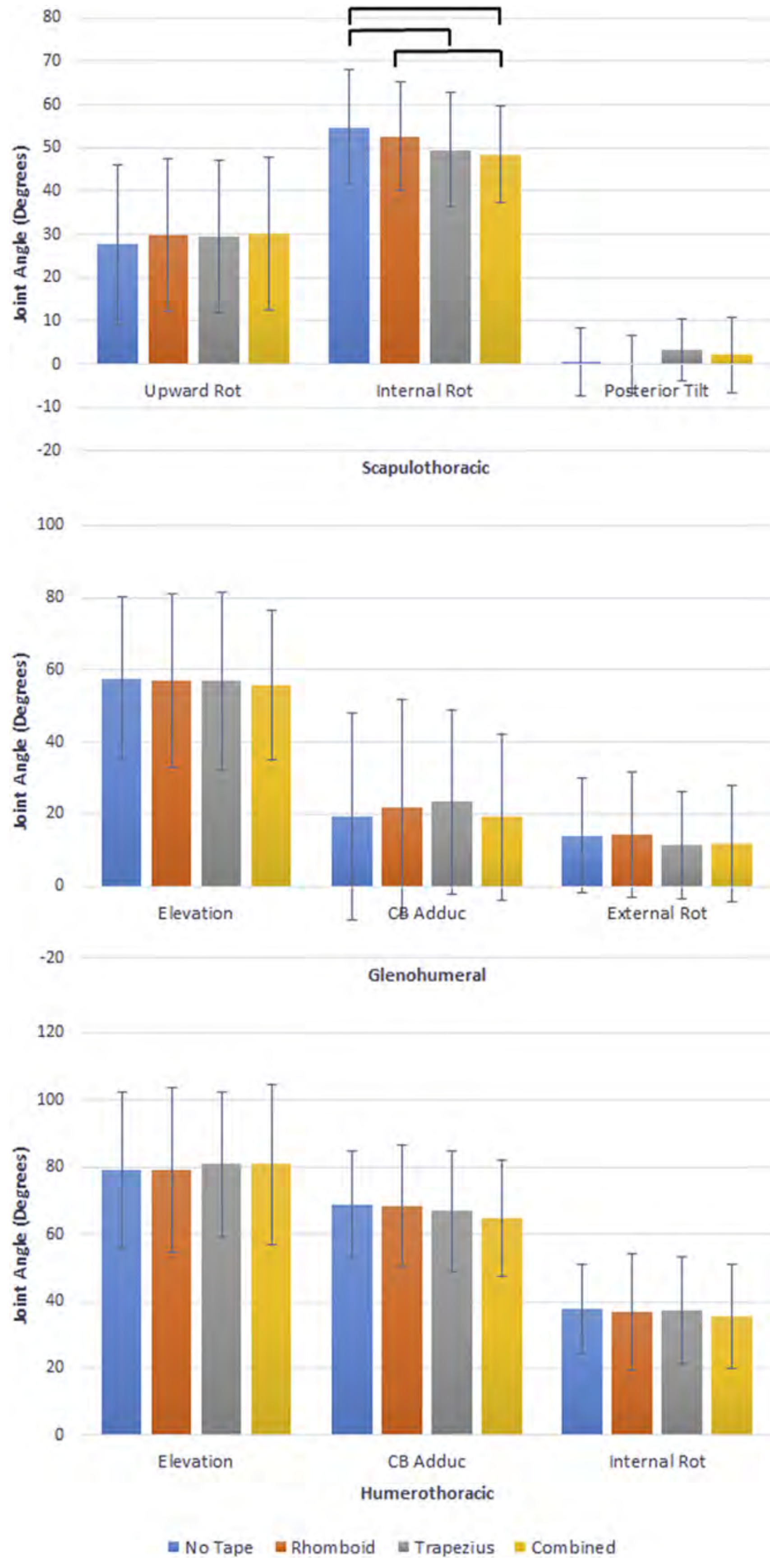

Fig. 6. The scapulothoracic, glenohumeral, and humerothoracic joint angles are shown for the hand to mouth position. Each taping condition is represented by a separate bar. The significantly different joint angles are indicated by the black brackets. All *P* values for the multivariate analyses of variance and univariate analyses of variance were less than .017. The *P* values for the post hoc, Bonferroni, and pairwise comparisons (shown by the black brackets) were all less than .05. CB Adduc = crossbody adduction.

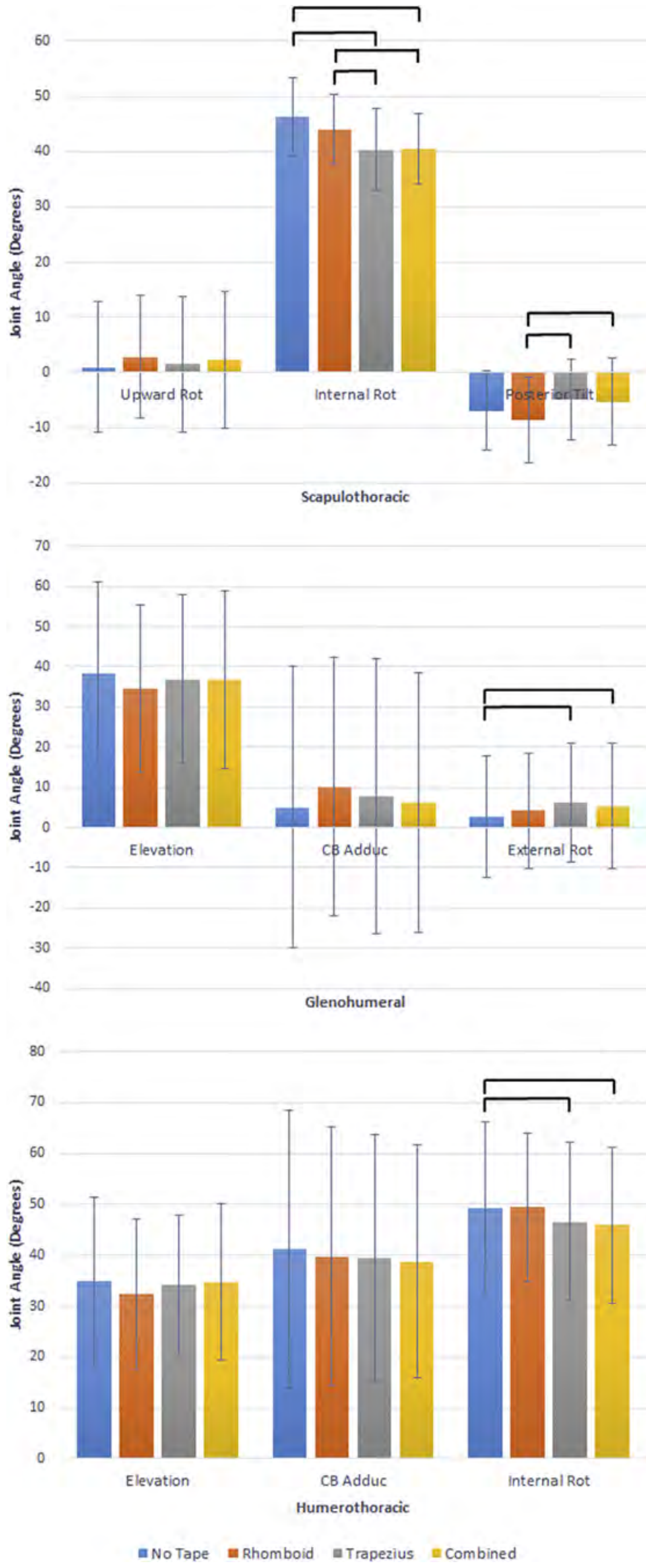

Fig. 7. The scapulothoracic, glenohumeral, and humerothoracic joint angles are shown for the internal rotation position. Each taping condition is represented by a separate bar. The significantly different joint angles are indicated by the black brackets. All *P* values for the multivariate analyses of variance and univariate analyses of variance were less than .017. The *P* values for the post hoc, Bonferroni, and pairwise comparisons (shown by the black brackets) were all less than .05. CB Adduc = crossbody adduction.

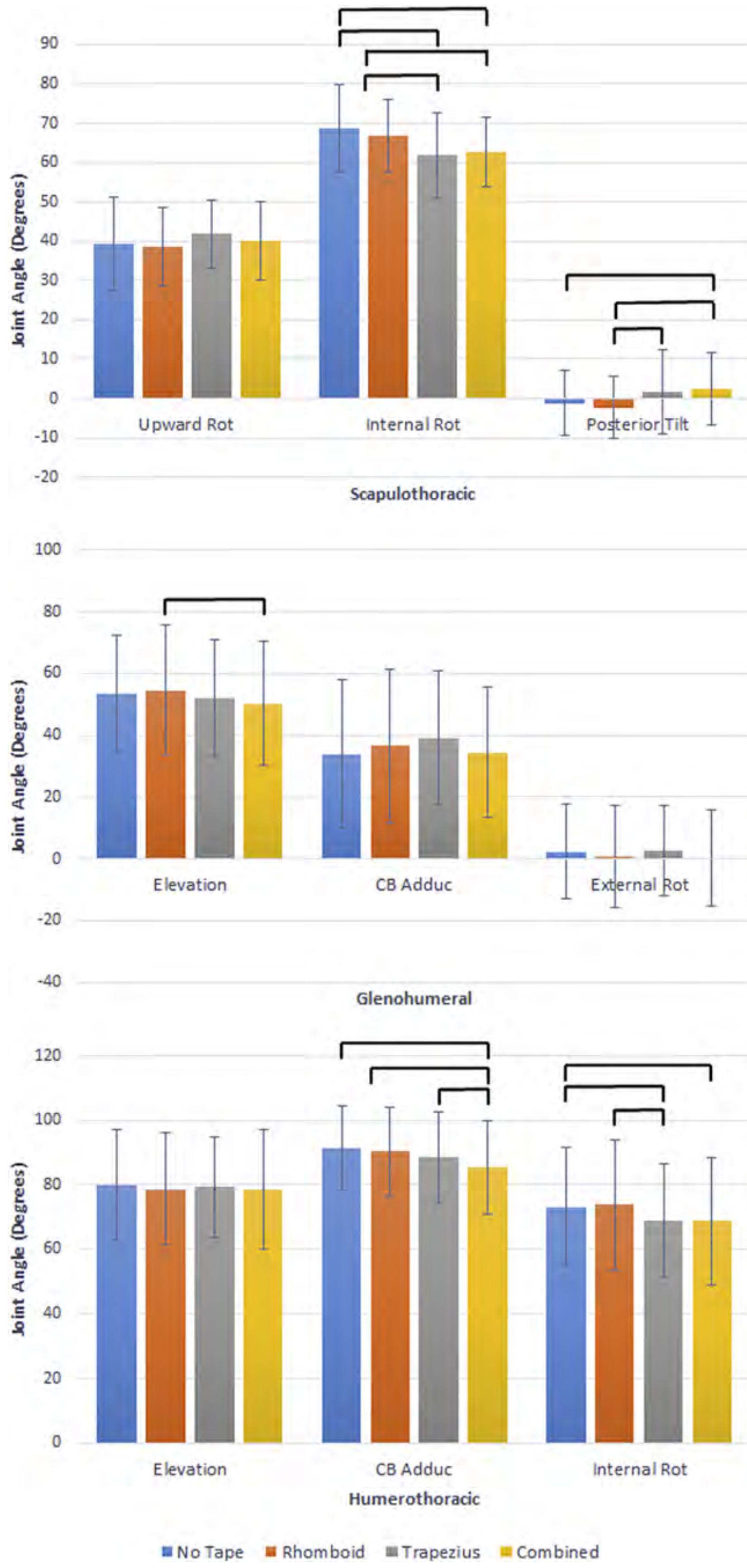

Fig. 8. The scapulothoracic, glenohumeral, and humerothoracic joint angles are shown for the crossbody adduction position. Each taping condition is represented by a separate bar. The significantly different joint angles are indicated by the black brackets. All *P* values for the multivariate analyses of variance and univariate analyses of variance were less than .017. The *P* values for the post hoc, Bonferroni, and pairwise comparisons (shown by the black brackets) were all less than .05. CB Adduc = crossbody adduction.

Table 2
The mean ± SD of the ST, GH, and HT joint angles are shown in degrees for each position and taping condition

Position	Joint angle	No tape	Rhomboid	Trapezius	Combined	Wilk's lambda	ANOVA
		Mean ± SD					*P*
Neutral	ST up rot	0.8 ± 6.3	2.7 ± 7.7	4.2 ± 10.5	2.9 ± 9.5	<0.001*	.096
	ST IR	43.8 ± 5.6	43.0 ± 7.3	36.9 ± 6.5	37.0 ± 5.7		<.001*
	ST post tilt	−6.1 ± 6.6	−7.4 ± 7.0	−5.0 ± 6.6	−5.8 ± 7.1		.003*
	GH elevation	27.0 ± 12.6	24.8 ± 13.3	26.5 ± 14.9	26.6 ± 15.1	0.013*	.321
	GH CBA	10.8 ± 29.8	14.4 ± 33.0	24.9 ± 37.7	20.2 ± 29.6		.044
	GH ER	8.1 ± 18.0	7.0 ± 17.5	5.9 ± 16.8	4.5 ± 17.8		.019
	HT elevation	23.8 ± 10.2	22.7 ± 9.6	25.9 ± 9.8	25.1 ± 10.0	<0.001*	.001*
	HT CBA	42.9 ± 19.5	40.1 ± 20.6	45.1 ± 18.2	38.1 ± 6.1		.143
	HT IR	36.3 ± 19.1	37.1 ± 19.2	31.8 ± 18.6	33.3 ± 18.1		<.001*
Hand to mouth	ST up rot	27.6 ± 18.5	29.9 ± 17.6	29.6 ± 17.6	30.1 ± 17.6	<0.001*	.664
	ST IR	54.8 ± 13.2	52.7 ± 12.6	49.5 ± 13.3	48.5 ± 11.2		<.001*
	ST post tilt	0.6 ± 7.9	−0.1 ± 6.6	3.2 ± 7.2	2.1 ± 8.7		.032
	GH elevation	57.6 ± 22.8	57.1 ± 24.1	56.8 ± 24.6	55.7 ± 20.6	0.136	.736
	GH CBA	19.1 ± 28.7	21.8 ± 30.1	23.4 ± 25.6	19.1 ± 23.2		.305
	GH ER	14.0 ± 15.9	14.3 ± 17.4	11.2 ± 14.9	11.8 ± 16.2		.113
	HT elevation	79.3 ± 23.1	79.2 ± 24.4	80.8 ± 21.7	80.8 ± 23.7	0.504	.640
	HT CBA	68.8 ± 16.0	68.4 ± 18.4	66.9 ± 18.1	64.9 ± 17.4		.131
	HT IR	37.8 ± 13.3	36.8 ± 17.4	37.4 ± 15.9	35.5 ± 15.4		.515
IR	ST up rot	1.0 ± 11.9	2.8 ± 11.1	1.5 ± 12.2	2.4 ± 12.4	<0.001*	.387
	ST IR	46.3 ± 7.1	44.1 ± 6.2	40.4 ± 7.4	40.5 ± 6.4		<.001*
	ST post tilt	−6.9 ± 7.2	−8.6 ± 7.8	−4.8 ± 7.3	−5.3 ± 7.9		<.001*
	GH elevation	38.4 ± 22.7	34.7 ± 20.9	36.9 ± 21.1	36.8 ± 22.0	0.001*	.059
	GH CBA	5.1 ± 34.9	10.2 ± 32.2	7.8 ± 34.3	6.3 ± 32.3		.296
	GH IR	2.6 ± 15.1	4.2 ± 14.3	6.2 ± 14.9	5.4 ± 15.7		.002*
	HT elevation	34.8 ± 16.6	32.4 ± 14.7	34.1 ± 13.7	34.7 ± 15.3	0.002*	.124
	HT CBA	41.1 ± 27.3	39.8 ± 25.5	39.4 ± 24.3	38.8 ± 23.0		.613
	HT IR	49.2 ± 16.9	49.4 ± 14.6	46.5 ± 15.6	45.9 ± 15.3		.016*
CBA	ST up rot	39.3 ± 11.8	38.6 ± 10.1	41.8 ± 8.8	40.0 ± 10.0	<0.001*	.364
	ST IR	68.6 ± 11.1	66.8 ± 9.3	61.8 ± 10.9	62.6 ± 8.9		<.001*
	ST post tilt	−1.2 ± 8.3	−2.3 ± 7.9	1.7 ± 10.7	2.4 ± 9.3		<.001*
	GH elevation	53.4 ± 18.8	54.6 ± 21.0	51.9 ± 18.9	50.3 ± 20.2	0.004*	.009*
	GH CBA	34.0 ± 23.9	36.6 ± 24.9	39.2 ± 21.5	34.4 ± 21.1		.105
	GH ER	2.4 ± 15.3	0.7 ± 16.5	2.5 ± 14.7	0.1 ± 15.5		.258
	HT elevation	79.9 ± 17.3	78.6 ± 17.5	79.3 ± 15.6	78.5 ± 18.8	<0.001*	.678
	HT CBA	91.4 ± 13.0	90.3 ± 13.9	88.5 ± 14.3	85.5 ± 14.4		<.001*
	HT IR	73.2 ± 18.5	73.8 ± 20.2	68.9 ± 17.8	68.7 ± 19.8		.003*

SD = standard deviation; ST = scapulothoracic; GH = glenohumeral; HT = humerothoracic; up rot = upward rotation; IR = internal rotation; post tilt = posterior tilt; CBA = crossbody adduction; ER = external rotation.
The Wilk's lambda is shown for the multivariate analyses of variance, along with the univariate analyses of variance *P* values. Bonferroni corrections for multiple comparisons were applied to both making the significance level .017. Significant *P* values are indicated by an asterisk (*).

of the dependent variables violated the sphericity assumption, as tested by Mulcahey's test. Therefore, the Greenhouse-Geisser correction was used. A Bonferroni correction was also applied to the univariate ANOVAs ($\alpha = 0.017$). Pairwise comparisons ($\alpha = 0.05$) were then performed for the significant univariate ANOVAs. The same statistical approach was repeated for each of the tested positions and for the joint angular displacements in each of the tested positions.

Results

Demographics

Participant demographic information and relevant surgical history are shown in Table 1.

Joint orientations

The ST, GH, and HT joint orientations are shown in Figures 5-8 and Table 2 for each position and taping condition. Both the trapezius taping and combined taping demonstrated significant ($P < .001$, P values listed in the text represent the pairwise comparisons unless otherwise noted) decreases in scapular winging as compared with no tape and/or rhomboids taping ranging from 4.2° to 6.9° in all positions (Fig. 9). There were also significant differences in ST posterior tilt in all positions except hand to mouth, as shown in Figures 5-8. GH internal rotation was significantly decreased in the internal rotation position for trapezius ($P = .003$) and combined ($P = .016$) tapings vs no tape. The participants also demonstrated significantly less ($P = .027$) GH elevation in the CBA position with combined taping compared with the rhomboids taping condition. Of the significant differences in HT joint angles shown in Figures 5-8, only 2 were greater than 5°: HT internal rotation in the neutral position in the trapezius compared with rhomboids taping conditions (5.3°, $P = .002$) and HT CBA in the CBA position in the combined vs no tape conditions (5.9°, $P = .026$).

Joint angular displacement

The only significant ($P = .004$, univariate ANOVA) change in joint angular displacement was less GH elevation in the trapezius (4.8°, $P = .033$) and combined (5.9°, $P = .009$) conditions compared with the rhomboid condition in the CBA position.

Discussion

ST, GH, and HT joint functions were similar for the no tape and rhomboids tape conditions with no significant differences between them. Similarly, the only significant difference in joint function between the trapezius and combined taping conditions was decreased HT CBA in the CBA position (3.0° less with combined

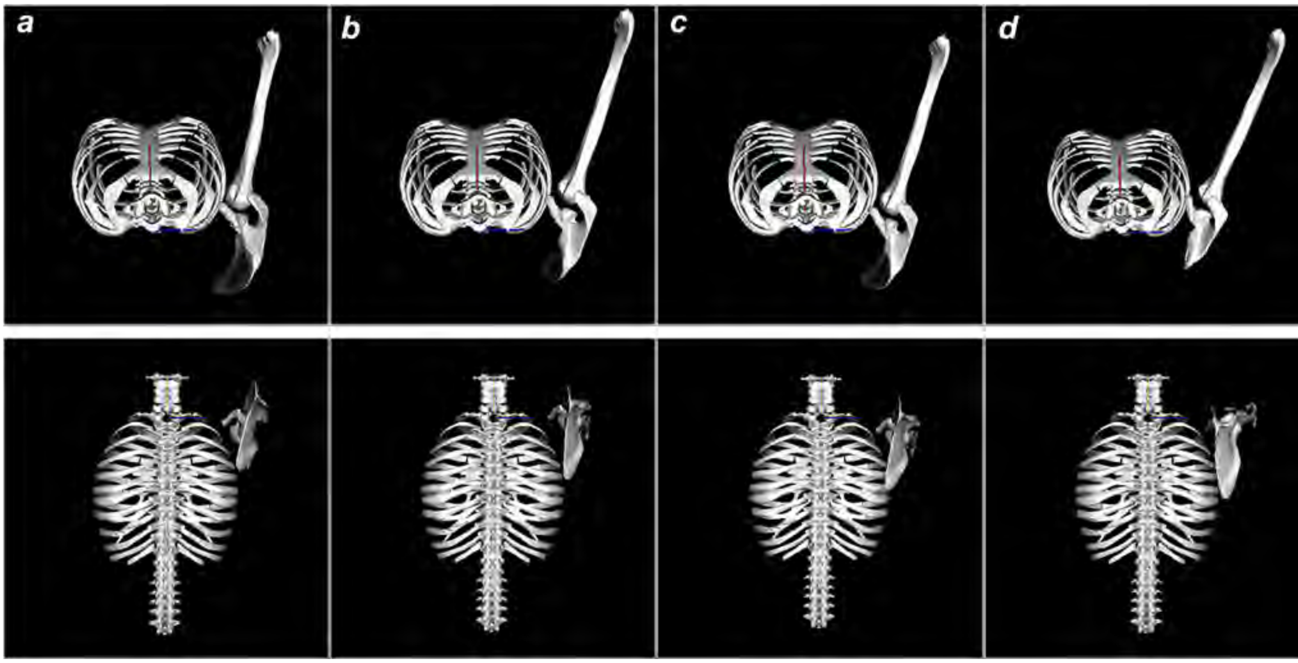

Fig. 9. Three-dimensional representations of the hand to mouth position of the same patient shown in Figure 3. Superior views (*top row*) and posterior views (*bottom row*) are shown for (**A**) no tape, (**B**) rhomboids tape, (**C**) trapezius tape, and (**D**) combined taping conditions.

taping, $P = .033$). Combined taping also significantly decreased HT CBA in the CBA position compared with the other taping conditions (no tape: $P = .025$, rhomboids tape: $P = .001$). In addition, combined taping significantly decreased ($P = .027$) GH elevation in the CBA position compared with rhomboids taping. Decreased HT CBA in the CBA position with combined taping represents less global shoulder CBA than the no tape, rhomboids taping, and trapezius taping conditions. Conversely, trapezius taping resulted in a similar reduction in scapular winging when compared with combined taping but without decreasing HT CBA in the CBA position. The combined taping may have excessively limited overall shoulder motion leading to an undesired decrease in HT CBA (Fig. 8).

Regarding the trapezius taping condition, there were only 2 significant findings that were not similarly reflected in the combined taping condition: a significant ($P = .008$) decrease in ST posterior tilt in the neutral position compared with rhomboids taping and a significant decrease in HT internal rotation (approximately 4°-5°) in the neutral position compared with both the no tape ($P = .011$) and rhomboid ($P = .002$) tape conditions. The clinical significance of the change in ST posterior tilt is unclear. It is likely related to the decrease in scapular winging as similar changes were found for the trapezius and/or combined conditions in the other tested positions. Decreased HT internal rotation in the neutral position represents an improvement in the typical HT internal rotation posturing of children with BPBP. This trend was also reflected in the combined tape condition. Trapezius taping resulted in similar statistically significant reductions in ST internal rotation (CBA motion of the scapula) in all positions without a significant loss in HT CBA in the CBA position.

Only 1 significant difference in the joint angular displacements (decreased GH elevation in the CBA position) was found. This indicates that the joint arcs of motion remained essentially unchanged for all other joints and positions. The resting orientations were altered with the application of trapezius and combined tape (demonstrated by the significant differences in the neutral position). These changes were largely maintained throughout the other motions evaluated in this study.

Overall, therapeutic taping to facilitate middle and lower trapezius was the most effective and beneficial scapular taping assessed in this study. There was no improvement in overall ability to perform the positions assessed in this study in the trapezius taping condition, aside from improved posture in the neutral position. Although trapezius taping was associated with decreased HT internal rotation in the internal rotation position compared with rhomboids taping, and in the CBA position compared with no tape (2.7° and 4.3°, respectively), the clinical significance of changes of these magnitudes was minimal. The findings of this investigation agree with previous findings of clinically small but statistically significant decreases in scapular winging with the application of Kinesio tape to facilitate the middle and lower trapezius.[12] In addition, although there were more statistically significant changes in HT joint orientations in this study, most of them occurred in conditions that were not evaluated in the previous literature.[12] The remainder were either clinically favorable (less HT internal rotation in the neutral position) or very small changes (less than 3° decrease in HT internal rotation in the internal rotation position). There were fewer significant differences in GH joint orientation in the present study than in previously reported findings.[12] This raises the question of whether therapeutic Kinesio taping for scapular stabilization has the potential to exert a positive effect on GH joint development as suggested in a previous study[12] and demonstrated in a case study by Walsh.[54] Finally, the previous study investigating the effect of trapezius taping also found no significant changes in joint angular displacement.[12]

There were limitations associated with this study. The participants performed the same arm positions 4 times (once for each taping condition), which theoretically could result in improved performance due to a learning effect. The order that the taping conditions were collected in was rotated for each child. This ensured that a quarter of the participants completed each taping condition first, second, third, and fourth to mitigate the impact of a potential learning effect. In addition, the possibility of a placebo effect with application of therapeutic tape was not investigated. However, the lack of significant differences in the rhomboids taping condition suggests that there was no placebo effect. Collecting multiple trials for each position and taping condition would allow for improved assessment of reliability. The data collection protocol was limited to 1 trial to ensure that children of all ages would be able to complete the protocol. The similarity between the no taping and rhomboids taping and between the trapezius and combined taping indirectly suggests that participants were performing the positions consistently.

Based on the findings of this study, therapeutic taping to facilitate the middle and lower trapezius consistently decreases scapular winging in children with BPBP and has small, but beneficial, effects on ST and GH joint functions. Rhomboids taping should be avoided as no benefit was found in isolation or in combination with trapezius taping. With no demonstration of statistically significant decreases in scapular winging, use of rhomboids taping may increase cost and comorbidities (ie, potential for skin irritation) without any clinical benefit. In general, therapeutic taping for facilitation of middle and lower trapezius improved posture by decreasing scapular winging in the neutral position, and this change in the resting ST orientation was maintained throughout the other tested positions. Despite the improved posture, performance of the positions assessed in this study was not significantly improved. Although middle and lower trapezius taping consistently decreases scapular winging, the clinical change is small, and long-term benefits remain unknown. Patient-specific factors, such as cost, time, potential for skin irritation, patient motivation, and others, need to be considered for each child when considering this treatment modality.

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#1. The taping technique
   a. is described in detail in the text of the study
   b. can only be seen in the figures
   c. utilizes standard issue athletic adhesive tape
   d. may only be applied by a therapist certified in the use of Kinesio Tape

#2. The following angular measures were recorded
   a. glenohumeral
   b. humerothoracic
   c. scapulothoracic
   d. all of the above

#3. Reduced scapular winging was seen with the _______________ method
   a. trapezius
   b. combined
   c. a & b above
   d. rhomboids

#4. Cross-body adduction was limited with the _______________ method
   a. rhomboid
   b. combined taping
   c. trapezius
   d. none of the above

#5. There was no significant evidence that taping of the rhomboids was effective
   a. true
   b. false

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