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INVITED REVIEW

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Systematic review of the effectiveness of Kinesio taping for children with brachial plexus injury

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Abstract

Objective: The purpose of this systematic review was to investigate the effectiveness of Kinesio taping on upper limb motor function in children with brachial plexus injury.

Data sources: Articles were identified through searches of the following databases: OVID, Web of Science, Science Direct, PubMed, Google Scholar, and the Cochrane library.

Methods: Studies were excluded if they were nonpeer-reviewed publications, opinion articles, or not reported in English. The methodological quality of the studies was assessed using the Methodological Index for Nonrandomized Studies.

Results: Five studies met our inclusion criteria. Two studies were included in the meta-analysis. A significant change was limited only to scapulothoracic internal rotation in three positions.

Conclusions: Adding Kinesio taping to the physical therapy programme to manage children with brachial plexus injury is still questionable and may help functional improvement. However, this improvement may be limited depending on the technique or mode of application.

KEYWORDS

brachial plexus (MeSH heading tree number: A08.800.800.720.050 Unique ID: D001917), therapeutics (MeSH heading tree number: E02 Unique ID: D013812), upper extremity (MeSH heading tree number: A01.378.800 Unique ID: D034941)

1 | INTRODUCTION

Incomplete recovery of nerves in brachial plexus injury in 2- to 3-year-old children results in residual deficits. These residual deficits cause upper extremity muscle imbalance and joint contractures, which affect daily activities (Hale, Bae, & Waters, 2010). Brachial plexus birth palsy (BPBP) is a disturbing form of a cervical nerve injury that frequently leads to significant physical disability, and its incidence ranges globally between 0.15 and 5 per thousand live births, with higher numbers in developing countries (Coroneos et al., 2015). BPBP can occur during late pregnancy or delivery as a consequence of compression or traction injury to any of the brachial plexus parts. Several studies have shown a full recovery rate of up to 90% with conservative treatment. However, this rate may drop to 70–80% with delayed monitoring of the residual deficits (Malessy & Pondaag, 2009). A common type of BPBP that affects the superior trunk of brachial plexus C5 and C6 is known as Erb's palsy (Abzug & Kozin, 2010). Injury to C5, C6, and C7 is referred to as extended Erb's palsy, which is the next most frequent type of BPBP (Hale et al., 2010). Although some infants fully recover, approximately one third of these patients experience lifelong complications (Pondaag, A Malessy, Gert van Dijk, & W M Thomeer, 2004).

Residual defects of BPBP result in anatomical changes, motion deficits of the affected upper extremity such as reduced limb length and girth (Abzug & Kozin, 2010; Bae, Ferretti, & Waters, 2008), abnormal scapular morphology such as scapular winging (protrusion of the scapula away from the chest wall) (Duff, Dayanidhi, & Kozin, 2007), glenohumeral dysplasia (Bhardwaj, Burgess, Sabapathy, Venkataramani, & Ilayaraja, 2013), muscle weakness, and reduced range of motion (Dodwell et al., 2012).

Kinesio taping is a taping technique originated by Dr. Kenzo Kase in Japan >25 years ago. This therapeutic technique is applied as an alternative to athletic taping to support the fascia, muscles, and joints; however, unlike athletic taping, Kinesio taping allows for unlimited range of motion (ROM) and decreases the time for recovery from injury by reducing pain and inflammation (Mostafavifar, Wertz, & Borchers, 2012). The tape is made of cotton with an antiallergic adhesive layer that allows for evaporation and quick drying. These properties make it comfortable to be worn for a long period ranging from 3 to 5 days at a time. The tape is water resistant and has an elasticity of up to 140%.

The tape may be applied in different ways, such as the following: I shape (the strips are placed in the area above the muscle belly), Y shape (surrounding the muscle belly), X shape (from a central point surrounding the muscle belly), octopus shape (for lymph drainage), donut shape (to increase space), or star shape (to increase the central space) (ElKhatib, ElNegmy, Salem, & Sherief, 2013; Kamal-Eldeen, Awooda, Abd El-Maksoud, Nagaraju Ganji, & Hui, 2016). The creator of this technique has described its therapeutic effects, which will depend on the extent to which the tape is stretched and the shape of application (Thelen, Dauber, & Stoneman, 2008), given that it may be applied to any muscle or joint. In clinical practice, Kinesio taping is usually used to stimulate mechanoreceptors and increase sensory and proprioceptive feedback (Lee, Kim, Oh, & Chang, 2015; Zuk & Księzopolska-Orłowska, 2008), help support joint structures and biomechanical alignment (Kocyigit et al., 2015), and facilitate or inhibit muscle function (Reyhan, Dereli, & Çolak, 2017). As Kinesio taping improves sensory and proprioceptive feedback, which are prerequisites for proper motor development (Bayrakci Tunay et al., 2008), taping becomes an interesting resource to be added to paediatric rehabilitation.

Some studies have found that using Kinesio taping for treating children with brachial plexus injury may help to improve body structure and function, such as scapular stabilization, wrist extension, muscular function, ROM, and activities such as bilateral upper extremity play, weight bearing, hanging from playground equipment, and catching a playground ball (ElKhatib et al., 2013; Kamal-Eldeen et al., 2016; Walsh, 2010). Other studies found no improvement in performance during activity (Russo et al., 2016; Russo et al., 2017). A study by Walsh found improvements in active participation and exploration of the surrounding environment (Walsh, 2010).

Therefore, the purpose of this systematic review was to investigate the effectiveness of Kinesio taping on upper limb motor functions in children with brachial plexus injury.

2 | MAIN TEXT

2.1 | Methods

This study was based on the recommendations of the PRISMA statement for the preparation of systematic reviews (Moher et al., 2009; Shamseer et al., 2015).

2.1.1 | Searching strategy and study selection

The electronic database search was performed independently by two authors (the second and third authors) from January 1980 to June 2018; we searched the electronic databases in OVID, Web of Science, Science Direct, PubMed, Google Scholar, and the Cochrane library. The following key terms were used to search the electronic databases: "Brachial plexus injury," "Brachial plexus birth palsy," "Erb's palsy," "Erb engram," "Brachial plexus neuropathy," "Brachial plexus disorders," "Brachial plexopathy," "Klumpke paralysis," "Upper extremity strength," "Upper extremity function," "Fine motor," "Humero-thoracic function," "Gleno-humeral angles," "Scapular winging," "Upper limb activity," "Hand strength," "Pinch strength," "Kinesio tap," "Kinesio taping," "kinesiotape," "arm tap," "Therapeutic tape," and "Adhesive tape." The search yielded a total of 478 articles. Filtration by title and abstract was performed independently by two authors (the first and second authors), and then full-text filtration was performed independently by two authors (the first and second authors).

2.1.2 | Inclusion and exclusion criteria

The studies were included in this review based on the following criteria: (a) Participants included in the studies were children with brachial plexus injury, and their ages ranged from 1 month to 18 years, with no limitations on participant sex or nationality. (b) The intervention in the studies was Kinesio taping used as the sole intervention or as a part of the intervention. (c) All study designs were included. Studies were excluded if they were nonpeer-reviewed publications, opinion articles, or articles not reported in English.

2.1.3 | Data extraction and quality assessment

The following items were extracted independently by two authors (the first and second authors): authors, year of publication, study design, level of evidence, intervention characteristics, outcome measures, assessment, and functional outcomes according to the International Classification of Functioning, Disability and Health (ICF) classification (Who, 2001).

All articles that met the inclusion criteria were assessed for their quality independently by two authors (the first and second authors), and any disagreements were resolved by the third author. Quality assessment was performed using the Methodological Index for Nonrandomized Studies (MINORS; Slim et al., 2003). The MINORS

instrument has been determined to be valid and reliable for assessing the methodological quality of both randomized and nonrandomized studies. MINORS scores ranged from 0 to 24 for comparative studies and 0 to 16 for noncomparative studies. The following methodological items are evaluated with the MINORS instrument: aim of the study, inclusion of participants, prospective collection of data, and appropriate outcome assessments, unbiased assessments to the outcomes, follow-up, attrition, and sample size. In addition, the quality of the comparison group and statistical analyses in only comparative studies are assessed. Items on the MINORS tool are scored as 0, not reported; 1, reported but inadequate; and 2, reported and adequate. Each study was independently reviewed by two authors, after which the scores were compared and a decision on the final scores was made during a consensus meeting between the three authors. The National Health and Medical Research Council (NHMRC) Hierarchy of Evidence (Merlin, Weston, & Tooher, 2009) was used to categorize the studies' level of evidence.

2.2 | Results

2.3 | Selection of studies

The electronic search yielded 506 articles. After the exclusion of duplicates, there were 478 articles, of which 120 articles were excluded for using different interventions; 26 articles, for having different populations; and 327 articles, for using different interventions on different populations; and five articles met the inclusion criteria for analysis (Figure 1).

Tables 1 and 2 summarize the extracted data concerning the principal methodological aspects and functional outcomes of each study according to the ICF classification (WHO, 2001). The designs of the included studies were quasirandomized controlled trials, cross-sectional studies, case–control studies, and case reports. The studies came from two countries (Egypt and USA), and the publication date was until October 2017.

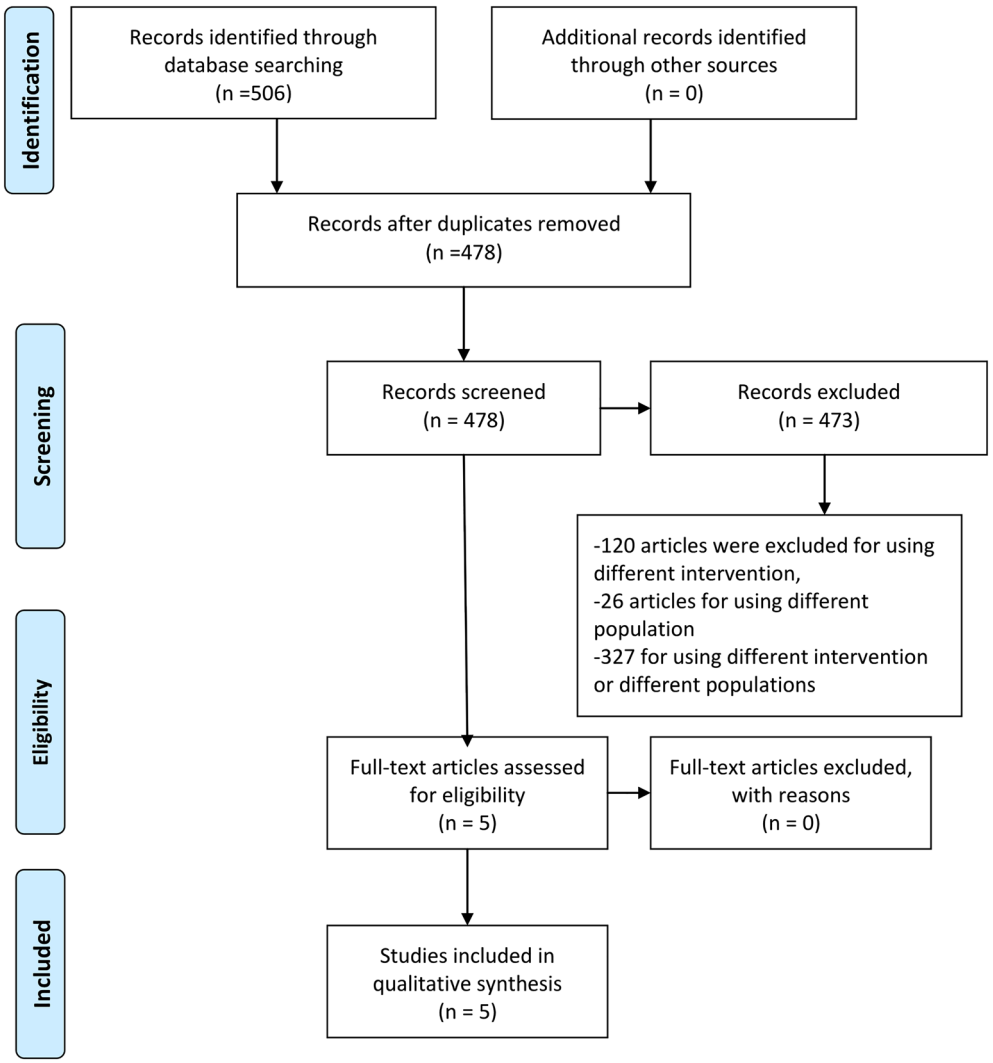


FIGURE 1 A flowchart of the articles

TABLE 1 Summary of studies characteristics

Study authors, year of publication, place	Study design and level of evidence	Participant and sample	Outcome measures	Intervention characteristics	Assessments
ElKhatib et al. (2013) Egypt	Quasirandomized control trials Level III-1	30 children with Erb's palsy ranged from 1 to 5 months	Electro Neurography TorontoActive Movement Scale	Children were divided into two groups (control and study) 15 children each Both groups received traditional physiotherapy treatment for 45 min, three times per week, for three successive months, whereas children in study group receive Kinesio tape for biceps and deltoid muscle for a period of 3 months	Preassessment Postassessment (after 12 week)
Kamal-Eldeen et al. (2016) Egypt	Case–control Level III-2	30 children with Erb's palsy ranged from 1 month to 3 years	Active movement scale Gilbert_Raimondi classification	Children were divided into two groups (control and study) 15 children each. Both groups received traditional physiotherapy treatment for 45 min daily for15 sessions, whereas children in study group receive Kinesio tape for wrist extension ms	Preassessment Postassessment (2 weeks)
Russo et al. (2017) USA	Cross-sectional Clinical measurement study Level IV	28 children with BPBP ranged from 5 to 17 years	10 camera motion capture system Custom written software Modified mallet classification	Each child was assessed by a licensed occupational therapist to confirm suitability for scapular stabilization with 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	Preassessment Postassessment (immediately after application)
Russo et al. (2016) USA	Cross-sectional study Level IV	26 children with BPBP ranged from 5 to 17 years	Eight camera motion capture system Helical angles and modified globe method	A licensed occupational therapist confirm suitability for scapular stabilization with taping The occupational therapy assessment consisted of a subjective evaluation of increased scapular winging (compared with the contralateral limb)	Preassessment Postassessment (immediately after application)
Walsh (2010) USA	Case report Single-subject design	One child with brachial plexus injury 2 years old	X-rays The mallet system	Taping to facilitate rotator cuff and scapular stabilization began and continued (2–3) day on, (1–2) day off through (20 weeks)	Preassessment Postassessment (after 2, 4, 10, and 20 weeks)

Abbreviation: BPBP, brachial plexus birth palsy.

TABLE 2 Functional outcomes for the included studies according to ICF classification

Study	Body structure and function	Activity	Participation
ElKhatib et al. (2013)	Significant improvement in muscular function (p value was .048 for deltoid and .021 for the biceps muscle). Significant improvement in shoulder flexion, abduction, elbow flexion, and radio-ulnar supination (p values were .006, .024, .000, and .000, respectively)	Significant improvement in upper extremity function and control, motor learning	—
Kamal-Eldeen et al. (2016)	Significant improvement in wrist extension range of motion (active movement scale p = .006; Gilbert Raimondi classification p = .02)	Significant improvement in functional activity	—
Russo et al. (2017)	There was no improvement in overall ability. A significant increase in scapular stabilization (p < .001) in resting posture	Not significant improvement in performance during activity	—
Russo et al. (2016)	A small but statistically significant decrease in scapular winging (p < .001), increase glenohumeral cross body adduction and internal rotation	Overall performance was largely unchanged	—
Walsh (2010)	Significant improvement in humeral head position and deltoid definition, shoulder symmetry, scapular stabilization, and the range of motion (Mallet score was 20/25)	Significant improvement in bilateral upper extremity weight bearing activities	Significant improvement in bilateral upper extremity play, hanging by playground equipment, and catching a playground ball Significant improvement in active participation and exploration of the surrounding environment

2.3.1 | Study characteristics

The five studies investigated a total of 115 children, and their ages ranged from 1 month to 18 years. Two studies (ElKhatib et al., 2013; Kamal-Eldeen et al., 2016) investigated 30 children divided into two groups (control and study) with 15 children each. In the study conducted by ElKhatib et al. (2013), both groups received traditional physiotherapy treatment for 45 min, three times per week, for three successive months, whereas children in the study group received Kinesio taping for the biceps and deltoid muscles for a period of 3 months. However, in the study conducted by Kamal-Eldeen et al. (2016), both groups received traditional physiotherapy treatment for 45 min daily for 15 sessions, whereas children in the study group received Kinesio taping for wrist extension muscles. The other two studies (Russo et al., 2016; Russo et al., 2017) investigated 26 and 28 children, respectively; each child was assessed by a licensed occupational therapist to confirm suitability for scapular stabilization with taping, and the assessment consisted of a subjective evaluation of increased scapular winging compared with the contralateral limb, which was readily improved. The last study (Walsh, 2010) was a case report that investigated a female child by applying tape to facilitate rotator cuff and scapular stabilization; the tape was kept on the application site for 2 to 3 days followed by 1 to 2 days off through 20 weeks. After the treatment, the two studies (Russo et al., 2016; Russo et al., 2017) focused on measuring the effect of the therapeutic taping technique of the middle and lower trapezius muscle on stabilizing the scapula and revealed that compared with no taping, trapezius taping resulted in a significant decrease (p < .001) in scapular winging ranging from 4.2 to 6.9 in all modified mallet positions. ElKhatib et al. (2013) investigated the effect of Kinesio taping over the deltoid and the forearm using electroneurography and the Toronto Active Motion Scale and showed a significant improvement for shoulder flexion and abduction, elbow flexion, and radio-ulnar supination, as their p values were .006, .024, .000, and .000, respectively, and better in muscle

innervation, as their p value was .048 for deltoid muscle and .021 for the biceps muscle. Kamal-Eldeen et al. (2016) assessed upper extremity strength using the Active Movement Scale and Gilbert–Raimondi classification and showed significant improvement in active wrist extension (Active Movement Scale p = .006; Gilbert–Raimondi classification p = .02) and functional activities. Walsh (2010) also assessed the muscular and functional activities of the shoulder by using the mallet system and showed significant progress of the deltoid muscle definition; the shoulders were level, and the scapula displayed less winging.

2.3.2 | Level of evidence and quality assessment

According to NHMRC's hierarchy of evidence, two studies had level III evidence (ElKhatib et al., 2013; Kamal-Eldeen et al., 2016), two studies had level IV evidence (Russo et al., 2016; Russo et al., 2017), and one study had a single-subject design (Walsh, 2010). The results of the quality assessment of the studies using MINORS are presented in Table 3. The investigations by ElKhatib et al. (2013) and Kamal-Eldeen et al. (2016) are two comparative studies with an average MINORS score of 12.5/24. The other three studies are noncomparative studies with an average MINORS score of 8.6/16 (Russo et al., 2016; Russo et al., 2017; Walsh, 2010). Walsh (2010) is the only study that conducted a follow-up at 2, 4, 10, and 20 weeks; thus, the follow-up item on MINORS Q6 (question 6) was scored as 2. In the studies of ElKhatib et al. (2013) and Kamal-Eldeen et al. (2016), the baseline equivalence of group item Q11 and the statistical analysis quality item on the MINORS tool Q12 were scored as 1 because in Q11, there was poor reporting regarding the baseline similarity of groups; furthermore, for Q12, the researchers addressed only the first part of the question, which was in accordance with the statistics for the type of study, but they did not calculate the confidence interval or the relative risk.

2.4 | Meta-analysis

This meta-analysis combined data at the study level. The outcome variable was scapular stabilization after taping the middle and lower trapezius muscle. To allow a comparison of data from different scales, pooled statistics were calculated using standardized mean differences, which were computed using the Comprehensive Meta-Analysis program (CMA, version 3.3.070). Means and *SD*s for the tape and no tape groups (when relevant) were used to compute standardized mean differences. If appropriate, the estimated effect size was calculated if the outcome variable was reported in ≥2 studies.

Scapular stabilization after taping the middle and lower trapezius muscle was a continuous outcome. The outcome was pooled across studies and analysed using a random-effect model for data collated from all eligible acute studies obtained from the review and data collated from all eligible intervention studies obtained from the review. A random-effect model was used because it involves the assumption of statistical heterogeneity across studies.

Heterogeneity was assessed between studies using the I^2 statistic to quantify the proportion of the total outcome attributed to variability among studies. The following values were used: I^2 = 0–30% (no heterogeneity); I^2 = 30–49% (moderate heterogeneity); I^2 = 50–74% (substantial heterogeneity); and I^2 = 75–100% (considerable heterogeneity). The statistical analysis was conducted by using the Comprehensive Meta-Analysis program for Windows (CMA, version 3.3.070, BioStat, Inc., USA).

2.4.1 | Scapular stabilization after taping the middle and lower trapezius muscle (neutral)

Two studies (Russo et al., 2016; Russo et al., 2017) assessed scapular stabilization after taping the middle and lower trapezius muscle (neutral) outcome (Table 4). For overall scapular stabilization after taping the middle and lower trapezius muscle effect, there was no significant change in scapulothoracic upward rotation (n = 2 studies, n = 40 participants, mean difference 0.28; 95% CI [−0.35, 0.90]; 0.381; I^2 = 0%). There was no significant change in scapulothoracic posterior tilt (n = 2 studies, n = 40 participants, mean difference 0.17; 95% CI [−1.39, 1.73]; 0.828; I^2 = 81%). There was a significant change in scapulothoracic internal rotation (ST IR) (n = 2 studies, n = 40 participants, mean difference −1.03; 95% CI [−1.69, −0.37]; 0.002; I^2 = 0%). There was no significant change in glenohumeral cross body abduction (GH CBA; n = 2 studies, n = 40 participants, mean difference 0.38; 95% CI [0.25, 1.00]; 0.236; I^2 = 0%). There was no significant change in glenohumeral external rotation (n = 2 studies, n = 40 participants, mean difference −0.23; 95% CI [0.86, 0.39]; 0.464; I^2 = 0%).

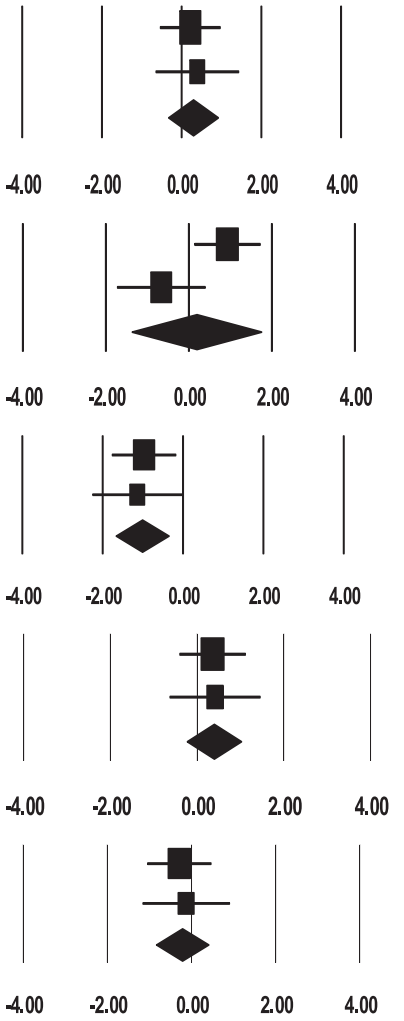
TABLE 3 Scores on the Methodological Index for Nonrandomized Studies (MINORS)

Item	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Score
ElKhatib et al. (2013)	2	2	2	2	1	0	0	0	2	0	1	1	13/24
Kamal-Eldeen et al. (2016)	2	2	2	2	0	0	0	0	2	0	1	1	12/24
Russo et al. (2016)	2	2	2	2	0	0	0	0	—	—	—	—	8/16
Russo et al. (2017)	2	2	2	2	0	0	0	0	—	—	—	—	8/16
Walsh (2010)	2	2	2	2	0	2	0	0	—	—	—	—	10/16

Abbreviation: Q, question.

TABLE 4 Meta-analysis of scapular stabilization after taping middle and lower trapezius muscle outcome (neutral)

Outcomes measured	Position	Joint angle	Study	Standardized mean difference [95% CI]	*p* value	Weight (%)	Standardized mean difference [95% CI]
Scapular stabilization after taping middle and lower trapezius muscle	Neutral	ST UR	Russo et al. (2016)	0.22 [−0.55, −0.99]	.580	65.30	
			Russo et al. (2017)	0.39 [−0.67, −1.45]	.467	34.70	
			Test for overall effect	0.28 [−0.35, −0.90]	.381		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.793); I^2 = 0%				
		ST PT	Russo et al. (2016)	0.93 [0.12, 1.74]	.024	63.89	
			Russo et al. (2017)	−0.67 [−1.74, 0.41]	.226	36.11	
			Test for overall effect	0.17 [−1.39, 1.73]	.828		
			Heterogeneity: τ^2 = 1.035; *df* = 1 (0.020); I^2 = 81%				
		ST IR	Russo et al. (2016)	−0.97 [−1.78, −0.16]	.019	65.87	
			Russo et al. (2017)	−1.14 [−2.27, −0.008]	.048	34.13	
			Test for overall effect	−1.03 [−1.69, −0.37]	.002		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.814); I^2 = 0%				
		GH CBA	Russo et al. (2016)	0.36 [−0.42, 1.13]	.364	65.12	
			Russo et al. (2017)	0.42 [−0.64, 1.47]	.442	34.88	
			Test for overall effect	0.38 [−0.25, 1.00]	.236		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.933); I^2 = 0%				
		GH ER	Russo et al. (2016)	−0.29 [−1.06, 0.48]	.462	64.81	
			Russo et al. (2017)	−0.13 [−1.17, 0.92]	.813	35.19	
			Test for overall effect	−0.23 [−0.86, 0.39]	.464		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.805); I^2 = 0%				



Abbreviations: CI, confidence interval; *df*, degrees of freedom (*n* − 1); GH CBA, glenohumeral cross body abduction; GH ER, glenohumeral external rotation; ST IR, scapulothoracic internal rotation; ST PT, scapulothoracic posterior tilt; ST UR, scapulothoracic upward rotation.

2.4.2 | Scapular stabilization after taping the middle and lower trapezius muscle (hand of mouth)

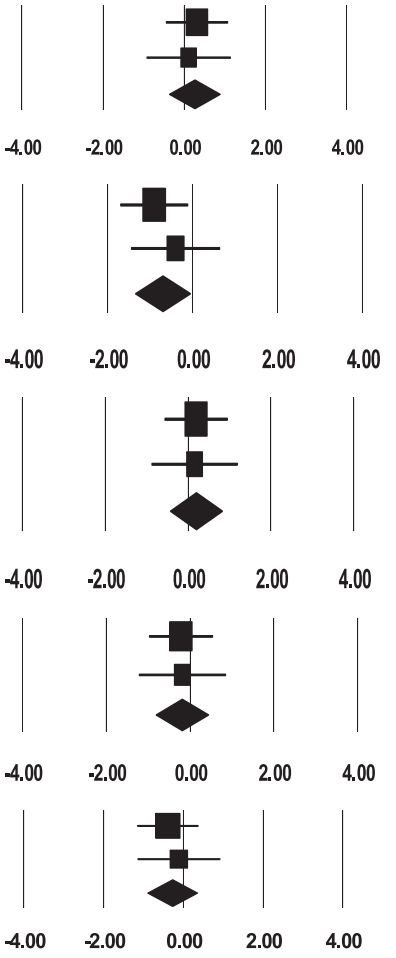
Two studies (Russo et al., 2016; Russo et al., 2017) assessed outcomes of scapular stabilization after taping the middle and lower trapezius muscle (hand of mouth; Table 5). For overall scapular stabilization after taping the middle and lower trapezius muscle, there was no significant change in the scapulathoracic posterior tilt (*n* = 2 studies, *n* = 40 participants, mean difference 0.24; 95% CI [− 0.38, − 0.86]; 0.446; I^2 = 0%). There was a significant change in the scapulathoracic internal rotation (ST IR) (*n* = 2 studies, *n* = 40 participants, mean difference −0.72; 95% CI [1.36, −0.08]; 0.028; I^2 = 0%). There was no significant change in GH CBA (*n* = 2 studies, *n* = 40 participants, mean difference 0.18; 95% CI [−0.44, 0.80]; 0.566; I^2 = 0%). There was no significant change in glenohumeral external rotation (*n* = 2 studies, *n* = 40 participants, mean difference −0.20; 95% CI [0.83, 0.42]; 0.520; I^2 = 0%). There was no significant change in humerothoracic cross body abduction (*n* = 2 studies, *n* = 40 participants, mean difference −0.29; 95% CI [−0.91, 0.33]; 0.362; I^2 = 0%).

2.4.3 | Scapular stabilization after taping the middle and lower trapezius muscle (internal rotation)

Two studies (Russo et al., 2016; Russo et al., 2017) assessed outcomes of scapular stabilization after taping the middle and lower trapezius muscle (internal rotation; Table 6). For the effect of overall scapular stabilization after taping the middle and lower trapezius muscle, there was a significant change in ST IR (*n* = 2 studies, *n* = 40 participants, mean difference −0.87; 95% CI [−1.51, −0.22]; 0.009; I^2 = 0%). There was no significant change in GH CBA (*n* = 2 studies, *n* = 40 participants, mean difference −0.32; 95% CI [−0.32, 0.93]; 0.345; I^2 = 0%).

TABLE 5 Meta-analysis of scapular stabilization after taping middle and lower trapezius muscle outcome (hand of mouth)

Outcomes measured	Position	Joint angle	Study	Standardized mean difference [95% CI]	*p* value	Weight (%)	Standardized mean difference [95% CI]
Scapular stabilization after taping middle and lower trapezius muscle	Hand of mouth	ST PT	Russo et al. (2016)	0.31 [−0.46, 1.09]	.427	64.76	
			Russo et al. (2017)	0.11 [−0.94, 1.16]	.836	35.24	
			Test for overall effect	0.24 [−0.38, 0.86]	.446		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.761); I^2 = 0%				
		ST IR	Russo et al. (2016)	−0.90 [−1.71, 0.10]	.028	63.23	
			Russo et al. (2017)	−0.40 [−1.46, 0.66]	.459	36.77	
			Test for overall effect	−0.72 [−1.36, −0.08]	.028		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.460); I^2 = 0%				
		GH CBA	Russo et al. (2016)	0.20 [−0.58, 0.97]	.621	64.96	
			Russo et al. (2017)	0.16 [−0.89, 1.20]	.768	35.04	
			Test for overall effect	0.18 [−0.44, 0.80]	.566		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.956); I^2 = 0%				
		GH ER	Russo et al. (2016)	−0.22 [−0.99, 0.56]	.582	64.96	
			Russo et al. (2017)	−0.18 [−1.23, 0.87]	.734	35.04	
			Test for overall effect	−0.20 [−0.83, 0.42]	.520		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.958); I^2 = 0%				
		HT CBA	Russo et al. (2016)	−0.39 [−1.16, 0.39]	.327	64.61	
			Russo et al. (2017)	−0.11 [−1.16, 0.94]	.835	35.39	
			Test for overall effect	−0.29 [−0.91, 0.33]	.362		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.678); I^2 = 0%				



Abbreviations: CI, confidence interval; *df*, degrees of freedom (*n* − 1); GH CBA, glenohumeral cross body abduction; GH ER, glenohumeral external rotation; HT CBA, humerothorathic cross body abduction; ST IR, scapulothoracic internal rotation; ST PT, scapulothoracic posterior tilt.

There was no significant change in glenohumeral internal rotation (*n* = 2 studies, *n* = 40 participants, mean difference 0.28; 95% CI [−0.34, 0.91]; 0.375; I^2 = 0%).

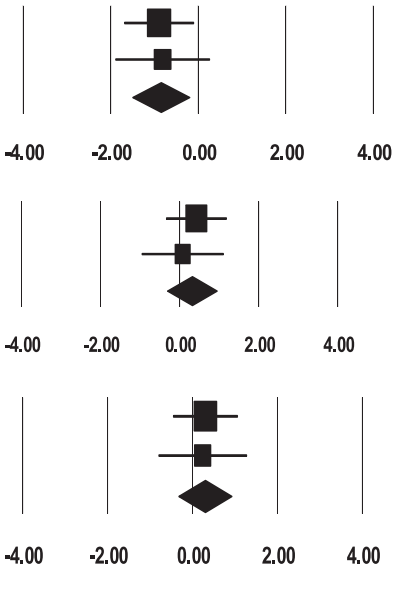
3 | DISCUSSION

The purpose of this systematic review was to investigate the effectiveness of Kinesio taping on upper limb motor functions in children with brachial plexus injury. This review included studies published until June 2018 and retrieved from PubMed, OVID, Web of Science, Science Direct, Google Scholar, and the Cochrane library.

Although Kinesio taping has been widely used in orthopaedic and sports injury management, it is a relatively new technique used to treat upper limbs in children with BPBP. Using Kinesio taping in the rehabilitation programme in conjunction with the regular physical therapy programme may help accelerate healing and promote a better, earlier, and smoother recovery in the affected arm of infants following BPBP (ElKhatib et al., 2013). Kinesio taping may be added to occupational therapy programmes in acute paediatric rehabilitation clinics to help improve upper extremity control and function (Yasukawa, Patel, & Sisung, 2006). In the case of more permanent damage/pathology in older children, Kinesio taping can possibly assist in improving joint position, stability, and ROM, which may assist upper limb function (Russo et al., 2016; Russo et al., 2017). Assisting upper limb function may help to improve participation. The only study that assessed the impact of using Kinesio taping on participation was the study by Walsh (2010), who reported an improvement in bilateral upper extremity play, hanging from playground equipment, and catching a playground ball; however, that study was a case report, and the results could not be generalized. Although the comparative studies (ElKhatib et al., 2013; Kamal-Eldeen et al., 2016) had the strength of the presence of an adequate control group, they had poor reporting regarding the baseline similarity of data. Two studies (Russo et al., 2016; Russo et al., 2017) had similar data and tested the effect of the therapeutic taping of

TABLE 6 Meta-analysis of scapular stabilization after taping middle and lower trapezius muscle outcome (internal rotation)

Outcomes measured	Position	Joint angle	Study	Standardized mean difference [95% CI]	*p* value	Weight (%)	Standardized mean difference [95% CI]
Scapular stabilization after taping middle and lower trapezius muscle	Internal rotation	ST IR	Russo et al. (2016)	−0.90 [−1.70, −0.09]	.030	64.64	
			Russo et al. (2017)	−0.81 [−1.90, 0.28]	.144	35.36	
			Test for overall effect	−0.87 [−1.51, −0.22]	.009		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.906); I^2 = 0%				
		GH CBA	Russo et al. (2016)	0.42 [−0.35–1.20]	.285	64.51	
			Russo et al. (2017)	0.08 [−0.97–1.13]	.884	35.49	
			Test for overall effect	0.30 [−0.32–0.93]	.345		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.603); I^2 = 0%				
		GH IR	Russo et al. (2016)	0.31 [−0.47–1.08]	.440	64.90	
			Russo et al. (2017)	0.24 [−0.81–1.29]	.655	35.10	
			Test for overall effect	0.28 [−0.34–0.91]	.375		
			Heterogeneity: τ^2 = 0.0001; *df* = 1 (0.923); I^2 = 0%				



Abbreviations: CI, confidence interval; *df*, degrees of freedom (*n* − 1); GH CBA, glenohumeral cross body abduction; GH IR, glenohumeral internal rotation; ST IR, scapulothoracic internal rotation.

the middle and lower trapezius muscle on stabilizing the scapula in children with brachial plexus injury; thus, these studies were included in the meta-analysis. Both studies (Russo et al., 2016; Russo et al., 2017) concluded that the middle and lower trapezius taping technique improves scapular stabilization. A meta-analysis was conducted to assess scapular stabilization after taping the middle and lower trapezius in both studies in three positions on the mallet system (neutral/hand to mouth/internal rotation). ST IR, upward rotation, posterior tilt and glenohumeral internal rotation, external rotation, cross body abduction, and humerothoracic cross body abduction were assessed in the three positions. A significant change was limited only to ST IR in the three positions. Both studies (Russo et al., 2016; Russo et al., 2017) gave some value to the immediate effect of Kinesio taping, but they did not guarantee the ongoing effects, as they lacked a follow-up period.

In the studies of ElKhatib et al. (2013), Kamal-Eldeen et al. (2016), and Walsh (2010), the participants were in the first 3 years of life. Meanwhile, in the studies of Russo et al. (2016) and Russo et al. (2017), the age range of their participants was from 5 to 17 years. Because the age of the participant is a key factor that affects the aim and the outcome of treatment, the heterogeneity of the age range in the reviewed studies limits the ability to draw a definite conclusion for a specific age group.

The above findings make it difficult to draw a clear decision about the effectiveness of Kinesio taping. The currently available research on using Kinesio taping in children with brachial plexus injury does not provide strong evidence about its effectiveness, and more studies with higher evidence and quality are needed to confirm the effectiveness of Kinesio taping in these particular cases.

4 | STUDY STRENGTHS AND LIMITATIONS

The strength of this review was that we had specific inclusion criteria and focused on specific outcomes to investigate the effectiveness of Kinesio taping in children with BPBP to help clinicians make a decision on using Kinesio taping in such children. However, we did not find any RCTs; moreover, there was a wide age range of participants and a small number of low quality studies. These facts are considered weak points of this analysis.

5 | CONCLUSION

Adding Kinesio taping to the physical therapy programme to manage children with brachial plexus injury is still questionable and may help functional improvement; however, this improvement may be limited depending on the technique or mode of application. Studies with a higher level of evidence and quality are needed to provide better evidence on the effect of using Kinesio taping in the treatment of children with brachial plexus injury, and the results should be interpreted carefully in terms of the specific technique and mode of application.

6 | IMPLICATION FOR PHYSIOTHERAPY PRACTICE

Kinesio taping has become of interest in the management of children with brachial plexus injury. Adding Kinesio taping to the treatment programme in children with brachial plexus injury may have a limited

effect depending on the technique of application, and this effect should not be overestimated.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All people named as authors meet all four criteria of the ICMJE.

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REFERENCES

Abzug, J. M., & Kozin, S. H. (2010). Current concepts: Neonatal brachial plexus palsy. *Orthopedics*, *33*(6), 430–435. https://doi.org/10.3928/01477447-20100429-25

Bae, D. S., Ferretti, M., & Waters, P. M. (2008). Upper extremity size differences in brachial plexus birth palsy. *The Hand*, *3*(4), 297–303. https://doi.org/10.1007/s11552-008-9103-5

Bayrakci Tunay, V., Akyüz, A., Önal, S., Güder Usgu, G., Doğan, G., Teker, B., & Çinar, Ö. (2008). Patellofemoral ağri sendromunda kinezyo ve McConnell patellar bantlama tekniklerinin performans üzerine anlik etkilerinin karşılaştirilmasi. *Fizyoterapi Rehabilitasyon*, *19*(3), 104–109.

Bhardwaj, P., Burgess, T., Sabapathy, S. R., Venkataramani, H., & Ilayaraja, V. (2013). Correlation between clinical findings and CT scan parameters for shoulder deformities in birth brachial plexus palsy. *The Journal of Hand Surgery*, *38*(8), 1557–1566. https://doi.org/10.1016/j.jhsa.2013.04.025

Coroneos, C. J., Voineskos, S. H., Coroneos, M. K., Alolabi, N., Goekjian, S. R., Willoughby, L. I., … Brouwers, M. C. (2015). Obstetrical brachial plexus injury: Burden in a publicly funded, universal healthcare system. *Journal of Neurosurgery. Pediatrics*, *17*(February), 1–8. https://doi.org/10.3171/2015.6.PEDS14703

Dodwell, E., O'Callaghan, J., Anthony, A., Jellicoe, P., Shah, M., Curtis, C., … Hopyan, S. (2012). Combined glenoid anteversion osteotomy and tendon transfers for brachial plexus birth palsy: Early outcomes. *Journal of Bone and Joint Surgery - Series A*, *94*(23), 2145–2152. https://doi.org/10.2106/JBJS.K.01256

Duff, S. V., Dayanidhi, S., & Kozin, S. H. (2007). Asymmetrical shoulder kinematics in children with brachial plexus birth palsy. *Clinical Biomechanics*, *22*(6), 630–638. https://doi.org/10.1016/j.clinbiomech.2007.02.002

ElKhatib, R. S., ElNegmy, E. H., Salem, A. H., & Sherief, A. A. A. (2013). Kinesio arm taping as prophylaxis against the development of Erb's Engram. *Journal of Advanced Research*, *4*(6), 485–491. https://doi.org/10.1016/j.jare.2012.08.006

Hale, H. B., Bae, D. S., & Waters, P. M. (2010). Current concepts in the management of brachial plexus birth palsy. *The Journal of Hand Surgery*, *35*(2), 322–331. https://doi.org/10.1016/j.jhsa.2009.11.026

Kamal-Eldeen, R. S., Awooda, H. A., Abd El-Maksoud, G. M., Nagaraju Ganji, P., & Hui, T. (2016). Effectiveness of kinesio tape on wrist extensor muscles in children with obstetric brachial plexus injuries. *Journal of Applied Life Sciences International Tiago Atalaia Portuguese Red Cross Health School, Portugal*, *7*(423), 1–7. https://doi.org/10.9734/JALSI/2016/27625

Kocyigit, F., Turkmen, M. B., Acar, M., Guldane, N., Kose, T., Kuyucu, E., & Erdil, M. (2015). Kinesio taping or sham taping in knee osteoarthritis? A randomized, double-blind, sham-controlled trial. *Complementary Therapies in Clinical Practice*, *21*(4), 262–267. https://doi.org/10.1016/j.ctcp.2015.10.001

Lee, D.-H., Kim, W.-J., Oh, J.-S., & Chang, M. (2015). Taping of the elbow extensor muscle in chronic stroke patients: Comparison between before and after three-dimensional motion analysis. *Journal of Physical Therapy Science*, *27*(7), 2101–2103. https://doi.org/10.1589/jpts.27.2101

Malessy, M. J. A., & Pondaag, W. (2009). Obstetric brachial plexus injuries. *Neurosurgery Clinics of North America*, *20*(1), 1–14. https://doi.org/10.1016/j.nec.2008.07.024

Merlin, T., Weston, A., & Tooher, R. (2009). NHMRC additional levels of evidence and grades for recommendations for developers of guidelines. *BMC Medical Research Methodology*, *9*(34), 1–23. https://doi.org/10.1186/1471-2288-9-34

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Mostafavifar, M., Wertz, J., & Borchers, J. (2012). A systematic review of the effectiveness of kinesio taping for musculoskeletal injury. *The Physician and Sportsmedicine*, *40*(4), 33–40. https://doi.org/10.3810/psm.2012.11.1986

Pondaag, W., A Malessy, M. J., Gert van Dijk, J., & W M Thomeer, R. T. (2004). Natural history of obstetric brachial plexus palsy: A systematic review. *Developmental Medicine and Child Neurology*, *46*(Table I), 138–144. https://doi.org/10.1111/j.1469-8749.2004.tb00463.x

Reyhan, A. Ç., Dereli, E. E., & Çolak, T. K. (2017). Low back pain during pregnancy and Kinesio tape application. *Journal of Back and Musculoskeletal Rehabilitation*, *30*(3), 609–613. https://doi.org/10.3233/BMR-160584

Russo, S. A., Rodriguez, L. M., Kozin, S. H., Zlotolow, D. A., Chafetz, R. S., Killelea, C. M., … Richards, J. G. (2016). Therapeutic taping for scapular stabilization in children with brachial plexus birth palsy. *American Journal of Occupational Therapy*, *70*(5), 1–11.

Russo, S. A., Zlotolow, D. A., Chafetz, R. S., Rodriguez, L. M., Kelly, D., Linamen, H., … Kozin, S. H. (2017). Efficacy of 3 therapeutic taping configurations for children with brachial plexus birth palsy. *Journal of Hand Therapy*, *31*, 31–34. https://doi.org/10.1016/j.jht.2017.03.001

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., … Whitlock, E. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ (Online)*, *349*(December 2014), 1–25. https://doi.org/10.1136/bmj.g7647

Slim, K., Nini, E., Forestier, D., Kwiatkowski, F., Panis, Y., & Chipponi, J. (2003). Methodological index for non-randomized studies (Minors): Development and validation of a new instrument. *ANZ Journal of Surgery*, *73*(9), 712–716. https://doi.org/10.1046/j.1445-2197.2003.02748.x

Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of Kinesio tape for shoulder pain: A randomized, double-blinded, clinical trial. *Journal of Orthopaedic & Sports Physical Therapy*, *38*(7), 389–395. https://doi.org/10.2519/jospt.2008.2791

Walsh, S. F. (2010). Treatment of a brachial plexus injury using kinesiotape and exercise. *Physiotherapy Theory and Practice*, *26*(7), 490–496. https://doi.org/10.3109/09593980903578872

WHO (2001). The international classification of functioning, disability and health. *World Health Organization*, *18*, 237. https://doi.org/10.1097/01.pep.0000245823.21888.71

Yasukawa, A., Patel, P., & Sisung, C. (2006). Pilot study: Investigating the effects of Kinesio Taping ® in an acute pediatric rehabilitation setting. *American Journal of Occupational Therapy*, *60*(1), 104–110. https://doi.org/10.5014/ajot.60.1.104

Zuk, B., & Księzopolska-Orłowska, K. (2008). Przydatność metody kinesio taping w chorobach zapalnych układu ruchu u dzieci. *Reumatologia*, *46*(6), 340–347.

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