



ORIGINAL ARTICLE

Kinesio arm taping as prophylaxis against the development of Erb's Engram



Radwa S. ElKhatib ^{a,*}, Emam H. ElNegmy ^a, Amina H. Salem ^b,
AbdelAziz A. Sherief ^a

^a Department of Physical Therapy for Pediatrics, Faculty of Physical Therapy, Cairo University, Egypt

^b Department of Pediatrics, Faculty of Medicine, Cairo University, Egypt

Received 2 April 2012; revised 13 August 2012; accepted 17 August 2012
Available online 1 October 2012

KEYWORDS

Erb's palsy;
Erb's Engram;
Toronto Active Motion
Scale;
Electroneurography;
Kinesiotaping

Abstract An Erb's Engram is a common debility that develops in recovering children with Erb's palsy. The purpose of this study was to investigate the effect of kinesiotaping over the deltoid and the forearm on the development of proper upper extremity function in children recovering from Erb's palsy. Thirty patients with Erb's palsy participated for 3 months in this study and were equally divided into two groups; control group A and study group B. The two groups received the same designed physical therapy program, while group B along the program, received kinesiotaping over the deltoid and the forearm. The subjects were evaluated, pre and post-treatment, and scored functionally, using the Toronto Active Motion Scale, and objectively, using an EMG device utilized to obtain the percentages of degeneration of the deltoid and the biceps muscles. Post-treatment values of six out of nine measured variables, between the two groups, revealed significant difference in favor of group B. The obtained results strongly support the introduction of kinesiotaping of the deltoid and the forearm as an adjunct to the treatment program of Erb's palsied children.

© 2012 Cairo University. Production and hosting by Elsevier B.V. All rights reserved.

Introduction

With improvement in obstetrical care, the incidence of brachial plexus injuries has decreased significantly. In countries in which obstetrical care is poor, OBPP is noted more frequently.

The incidence ranges globally from 0.2% to 4% of live births. According to the World Health Organization, prevalence is generally 1–2% worldwide, with the higher numbers being in underdeveloped countries. Duchenne–Erb type constitutes a major form among brachial plexus palsied children as it accounts about 80–90% of all brachial plexus palsied cases as a result of unilateral upper trunk lesion [1].

Erb's palsy results from stretching of the fifth and sixth cervical roots. The infant's arm is held in "waiter's tip" position, where the arm is extended and internally rotated, and the wrist is flexed. When there is an absent Moro reflex in the right arm, and the right hand grasp is intact, Erb's palsy should be suspected [2].

* Corresponding author. Tel.: +20 100 400 8503.

E-mail address: radwasaid@live.com (R.S. ElKhatib).

Peer review under responsibility of Cairo University.



Production and hosting by Elsevier

An Engram is thought to be a neural network or fragment of memory. As muscles are reinnervated in an asymmetric fashion, muscle imbalances occur in the shoulder that will virtually always lead to bone deformations in this group. Development of the brain-muscle connections is necessary for functional use of the newly reinnervated muscles. This can be achieved through a combination of neurorehabilitative techniques [3].

Furthermore, scapular growth is impaired compared to the normal side. The patients exhibit a persistent elbow-bent posture, pronation position of the forearm, and apparent shortening of the arm. In movement, there is loss of supination due to the abnormally situated arm in medial rotation, obvious elbow flare when the biceps is flexed, the “bugler’s position”, and awkward external rotation. This secondary structural shoulder deformity develops early and may persist despite improvement in neurological status [4].

Early treatment may entail physical and occupational therapy, daily passive range of motion exercises, Botulinum Toxin – A (BTX-A) injections, and/or splinting to lessen the severity of biceps/triceps co-contraction. Many times, however, deformations occur that require surgical intervention [5].

A very useful physiotherapeutic modality nowadays if applied properly is the kinesiology tape, which is a valuable adjunct to therapeutic rehabilitation [6,7]. It is a specialized tape which is thin, elastic and can be stretched up to 120–140% of its original length, making it quite elastic, compared with the conventional taping. It allows a partial to full range of motion for the applied muscles and joints with different pulling forces to the skin [6]. It is a technique that allows a therapist to work on more functional activities through improved proper alignment but with the tape acting as an extra hand [8]. The idea of kinesiotaping in brachial plexus palsies was introduced by Martin [7] in 2005 who concluded that techniques can be modified depending on innervation, sensory concerns and movement patterns to aid in the attainment of optimal alignment and attainment of developmental milestones. Since then, several recently published articles discuss the advantages of kinesiotaping in pediatric rehabilitation settings following nerve injury.

In the present study, we hypothesized that kinesiotaping of the shoulder and forearm will accelerate the healing of denervated muscles and delay, if not prevent, the occurrence of the Erb’s Engram. We, therefore, aimed to investigate the effect of kinesiotaping over the deltoid and the forearm on the development of proper upper extremity function in recovering children with Erb’s palsy.

Patients and methods

Subjects

After approving this study by the research ethical committee of our university, a quasi-randomized study of thirty children with Erb’s palsy selected from the out-patient clinic, Faculty of Physical Therapy, Cairo University (males and females, age ranged from 1 to 5 months) participated in this study.

Patients included in this study were diagnosed with unilateral obstetric brachial plexus palsy involving C5–6 and confirmed with positive findings of electroneurography

indicating innervation interruption for the deltoid and the biceps brachii muscles in the affected limb.

We did not include in this study children with musculoskeletal or neuromuscular abnormalities other than Erb’s palsy, contractures or fixed limitations in the affected upper extremity, and children with hypersensitivity to latex and adhesive tapes.

After sufficiently informing the parents about the procedure and signing a consent form, patients who met the inclusion criteria were assigned to one of two groups: group A (control), which received a designed physical therapy program; or group B (study), which received the same therapy program in addition to shoulder and forearm kinesiotaping. Subjects were gathered over the course of one year, and for that reason their assignments were intentionally achieved by allocating any subject, as soon as he/she was approved, into a group to maintain the mean of the muscles’ percentages of degeneration in the two groups close without any significant difference aiming for balance between the two groups.

Evaluative procedure

Electroneurography (ENoG) – Percentage of degeneration

For measuring the percentages of degeneration of the deltoid and the biceps brachii muscles, a computerized electromyographic apparatus (Neuroscreen plus – four channel – version 1.59 produced by TOENNIES, 97204 Hochberg, Germany) was used with surface electrodes.

To prepare the patient, he was placed supine on an examination table, bare skin from waist-up and the stimulating and the recording sites were cleaned with medical cotton damped with alcohol to reduce skin impedance. His head was maintained in mid position to avoid elicitation of any primitive reflexes, which will alter the tone distribution in his body.

ENoG was performed first on the healthy side and then repeated on the affected side. A bipolar stimulator was placed over the Erb’s point and manually adjusted to determine the best position to generate the compound muscle action potential (CMAP). For the deltoid, the active recording electrode was placed on the motor point of the posterior fibers of the deltoid muscle with the reference recording electrode placed farther distal on a relatively silent point, and for biceps muscle the active electrode was placed on the motor point of the biceps muscle also with the reference recording electrode placed farther distal on a relatively silent point.

The ground electrode was placed below the lateral 1/3 of the clavicle. A rectangular pulse with 5 ms timebase and a frequency of 1 Hz was produced. The stimulation current intensity was increased stepwise until there was no further increase in the amplitude of the diphasic myogenic CAP. An additional 10% of current was added to ensure supramaximal stimulation. The stimulation intensity ranged from 15 to 40 mA. The peak-to-peak amplitude was measured with the software included with the Neuroscreen plus system.

To calculate the percentages of degeneration the following equation [9] was used:

Percentage of degenerated fibers

$$= 100 - \left(\frac{\text{Amplitude of evoked response (in } \mu\text{V) Affected side}}{\text{Amplitude of evoked response (in } \mu\text{V) Normal side}} \times 100 \right)$$

Functional motor assessment

The Toronto Active Motion Scale "TAMS" (Table 1) [10] was used to assess the motor function of the shoulder flexors, shoulder extensors, shoulder abductors, shoulder external rotators, elbow flexors, radioulnar supinators and wrist-finger extensors.

Treatment procedures

Physical therapy treatment program

A designed 45 min physical therapy program was applied three times per week, for three successive months. It consisted of moist heat in the form of hot packs for 10 min; massage (thumb effleurage and spiral massage) starting from the distal part (hand) to the proximal one (shoulder and periscapular area) for 5 min and range of motion exercises 1 min for each joint. Then facilitation of muscle contraction of the affected muscles as rhomboids, deltoid, serratus anterior, elbow flexors, radioulnar supinators and wrist-finger extensors using the means used in muscle testing, proprioceptive stimulation, and righting and equilibrium reactions. The facilitation exercise was repeated for each muscle or group of muscles, for 20 times in the form of two sets of 10 repetitions, giving a 1 min rest in between the sets. At the end of the session, stretching was done for the tight muscles, such as subscapularis, pectoralis major, pronators, and wrist-finger flexors. Time of stretch was 20 s and 20 s were allowed for relaxation, repeated 3–5 times. A home program was explained for the caregiver to be given to the child; in the form of repetition of the exercises two times per day, good positioning of the affected limb and advices to dress the child's affected side first then the normal and undress the normal side first then the affected.

Kinesiotaping

Before therapeutic taping was conducted, skin sensitivity test was done by applying a square piece of kinesiotape (5×2.5 cm) over the back and kept for 48 h, then removed and the skin was observed for a reaction to the tape. Since no reaction was detected, the tape was applied for 3–5 days, then removed for 24 h to allow skin perspiration and then was reapplied again.

During application of the tape, the child received the designed physical therapy program according to his age and motor development. Repetition of tape application and removal was for a period of 3 months.

Table 1 The Toronto Active Motion Scale.

Observation	Muscle grade
<i>Gravity eliminated</i>	
No contraction	0
Contraction, no movement	1
Movement < ½ range	2
Movement > ½ range	3
Full movement	4
<i>Against gravity</i>	
Movement < ½ range	5
Movement > ½ range	6
Full movement	7

Shoulder taping was done using two kinesiotex tapes (2.5×7 cm), in the form of I shape. The tapes follow the line of pull of the anterior and posterior deltoid muscle fibers applied in order to assist the deltoid muscle action (Fig. 1a). The tape was applied with the child in a sitting position by assistance from his care giver, while the therapist supported the child's arm. The first tape was initiated from the upper border of the lateral 1/3 of the clavicle (origin of anterior fibers of the deltoid) to the deltoid prominence on the middle of the lateral side of the body of the humerus moving backward and lateralward while the arm was externally rotated and horizontally abducted. The second tape was initiated from the lower lip of the posterior border of the spine of the scapula (origin of the posterior fibers of the deltoid) towards also the humeral deltoid prominence moving forward and lateralward while the arm was horizontally adducted and internally rotated as if reaching to the outside of the contralateral hip.

Forearm taping was done using one kinesiotex tape (2.5×20 cm), in the form of I shape. With the elbow slightly flexed and the forearm in pronation, the tape was initiated from the anterior surface of the humeral lateral epicondyle, moving in a downward spiral manner passing the anterior surface of the upper 1/3 of the ulna, then continuing in the same manner passing the posterior aspect of the middle of the forearm and ending at the distal anterior border of the ulna (Fig. 1b).

Minimal stretch was applied to all tapes during application.

Statistical analysis

Statistical analysis of the data was performed using SPSS software for medical statistics. Descriptive analysis was used to analyze the sample's age and all variables measured (TAMS values and percentages of degeneration). To examine the values of TAMS between the two groups A and B and test significance, Mann–Whitney *U* test used, and to test significance between the pre and post-treatment values for each group separately, the Wilcoxon signed rank test was used.

To analyze the results of the percentages of deltoid's and biceps' degeneration, Chi-square (X^2) test was used to detect significance between groups A and B, and Wilcoxon signed rank test was used to detect significance between pre and post-treatment values for each group. Nominal two-tailed *p* values are reported. The significance level was set at $p < 0.05$.

Results

Patient characteristics

The study sample consisted of 30 patients divided equally into two groups A and B with a mean age of 1.66 and 2 months, respectively. Unpaired *t*-test proved matching between groups as they revealed that there was no significant difference between their ages. Their *t* and *p* values were 0.67 and 0.51, respectively.

Electroneurography results

Supramaximal stimulation conducted resulted in a mean percentage of degeneration of the deltoid muscle for group A and B of 68.7% and 71.27%, and of the biceps muscle of 69.87% and 69.35%, respectively. In accordance, there was no significant difference between the two groups (X^2 test,



Fig. 1 Kinesio tape applied over: (a) Deltoid's anterior and posterior fibers and (b) forearm in spiral manner.

Table 2 Descriptive analysis and Chi-square test of the percentages of degeneration of the deltoid and the biceps muscles between groups A and B, and Wilcoxon signed rank test of significance between pre- and post-treatment values in each of the two groups.

Variable		Median/IQR		χ^2	<i>p</i> Value
		Group A	Group B		
Deltoid muscle	Pre-treatment	76.05/42.15	75.65/38.5	0.347	0.805
	Post-treatment	34.25/43.47	17.45/27.5	0.460	0.048
	Z-test	-3.059	-3.059		
	Asymp. Sig. (2-tailed)	0.002	0.002		
Biceps muscle	Pre-treatment	87.65/58.25	72.7/33.55	0.404	0.961
	Post-treatment	57.65/61.13	22.9/41.15	0.347	0.021
	Z-test	-3.059	-3.059		
	Asymp. Sig. (2-tailed)	0.002	0.002		

IQR = Inter-quartile range, χ^2 = chi-square.

Z-test = Wilcoxon signed rank test based on positive ranks.

Statistical significance at $p < 0.05$.

deltoid $p = 0.805$ and biceps $p = 0.961$). Compared with the final outcome, using the Wilcoxon signed rank test, significant improvement were recorded between the pre- and post-treatment values among each of the two groups. The Chi-squared test of significance detected significant improvement in innervation in patients of group B over those in group A as their p value was 0.048 for the deltoid muscle and 0.021 for the biceps muscle, respectively (Table 2).

Functional motor assessment results

The clinical motor function at first presentation according to the Mann-Whitney U test showed no significance between the two groups where the p values of shoulder flexion, extension, abduction and external rotation, elbow flexion, radioulnar supination and wrist-finger extension were 0.763, 0.477, 0.905, 0.359, 0.976, 0.305 and 0.552 respectively. In the final outcome, significant improvement in group B over group A was recorded in shoulder flexion and abduction, elbow flexion and radioulnar supination as their p values were 0.006, 0.024, 0.000 and 0.000 respectively. While no significance was recorded between the two groups' values of shoulder extension and external rotation and wrist-finger extension and their p values were 0.091, 0.092 and 0.215 respectively.

Wilcoxon signed rank test was conducted to test significance of improvement between pre- and post-treatment values among each of the two groups showing significant improvement in all measured values for both groups (Table 3).

Discussion

History has shown that the great majority (95.7%) of obstetrical brachial plexus palsies do resolve spontaneously, with 92% of the recovery taking place during the first 3 months [11]. Regardless of the incidence of spontaneous recovery and the transient quality of the paralysis in some patients, contractures and deformities may occur rapidly. One should not await spontaneous recovery, as limitation of motion and deformity may persist, despite complete return of muscle power, if therapy is delayed [12]. The muscle imbalances and bony deformities occur because the denervated muscles do not grow at the same rate as their functional, opposing muscles [5]. Residual long-term deficits may include progressive bony deformities, muscle atrophy, joint contractures, possible impaired growth of limb, weakness of the shoulder girdle, and/or "Erb's Engram" (flexion of the elbow accompanied by abduction of shoulder) [13]. Therefore, correction of the supination deformity requires early intervention [14].

Interestingly, electromyography and nerve conduction velocity studies can show improvements in innervation before they manifest as movement. An EMG at 4–6 weeks sets a useful baseline with which to track recovery. Electrical improvements measured with a second EMG at 3–4 months, in combination with clinical observations, will allow a more thorough evaluation of recovery. As recovery progresses, new EMG studies indicate whether there are changes in the nerve's ability to conduct. EMG results can enhance the understanding of an injury

Table 3 Descriptive analysis and Mann–Whitney *U* test for significance of TAMS values between groups A and Band Wilcoxon test for significance between pre- and post-treatment values for each group.

Variable		Median/interquartile range		<i>U</i> -Test	<i>p</i> Value (2 tailed)
		Group A	Group B		
Shoulder flexion	Pre-treatment	1.5/4	2/4	67	0.763
	Post-treatment	5/3.75	6/0.75	26.5	0.006
	Z-test	-2.753	-3.078		
	<i>p</i> value (2 tailed)	0.006	0.002		
Shoulder extension	Pre-treatment	2.5/4.75	3/4	60	0.477
	Post-treatment	6/3	7/3	44.5	0.091
	Z-test	-2.675	-2.816		
	<i>p</i> value (2 tailed)	0.007	0.005		
Shoulder abduction	Pre-treatment	2.5/3	3/3	70	0.905
	Post-treatment	6/3.75	7/1	35.5	0.024
	Z-test	-2.827	-3.071		
	<i>p</i> value (2 tailed)	0.005	0.002		
Shoulder external rotation	Pre-treatment	2.5/3	2/2	56.5	0.359
	Post-treatment	6/3.5	6/1	44.5	0.092
	Z-test	-3.082	-3.097		
	<i>p</i> value (2 tailed)	0.002	0.002		
Elbow flexion	Pre-treatment	2/4.75	2.5/3.75	71.5	0.976
	Post-treatment	4.5/3	7/1	10	0.000
	Z-test	-2.555	-3.086		
	<i>p</i> value (2 tailed)	0.011	0.002		
Radioulnar supination	Pre-treatment	1/5	2.5/2.75	54.5	0.305
	Post-treatment	5/2.5	6/1	14	0.000
	Z-test	-2.661	-3.078		
	<i>p</i> value (2 tailed)	0.008	0.002		
Wrist extension	Pre-treatment	2/5	2.5/1	62	0.552
	Post-treatment	6/1.75	7/1	52.5	0.215
	Z-test	-2.816	-3.165		
	<i>p</i> value (2 tailed)	0.005	0.002		

U-test: Mann–Whitney *U* Test.

Z-test: Wilcoxon Signed Ranks Test based on negative ranks.

Statistical significance at $p < 0.05$.

during the recovery process [3]. Other studies oppose these findings stating that electrodiagnosis is often used to identify the level and extent of the lesion but with controversy as to whether nerve conduction studies and needle electromyography, typically performed at 3 months of age, are helpful in predicting recovery or selecting patients for reconstruction [15].

In this study, functional evaluation of the subjects was gained using the Toronto Active Motion Scale since in the first 3 years of life it is difficult to assess motion against resistance or measure the actual degree of motion in a reliable way [16].

A child with Erb's palsy is typically presented by adducted and internally rotated shoulder, extended and pronated elbow, and flexion of the wrist and fingers forming the characteristic "waiter's tip" posture. The deltoid, infraspinatus, biceps, supinator and brachioradialis muscles and extensors of the wrist and fingers may be weak or paralyzed [17]. It is worth noting that the pre-treatment mean grades of the TAMS showed a decrease in their value, which confirms that those children had weak active functions.

The weak active functions were also supported by the high mean values of the deltoid and biceps percentages of degeneration, which agrees with Oh [18] who confirmed that in the more common Erb's Palsy, the needle EMG shows denervation in the shoulder girdle muscles, and that the decreased

CMAP recorded off the affected side was initially due to impaired release of acetylcholine [19].

It has been established that physical therapy and other methods can minimize the occurrence of secondary and tertiary deformities [3], which is confirmed by the post-treatment results in this study that revealed significant improvement in the variables of the two groups A and B. The decrease in the mean values of the deltoid and biceps muscles' percentages of degeneration can be explained by the increase in the CMAP of the muscles of the affected sides recorded post-treatment since the exercises increase the presynaptic calcium concentration, which transiently facilitates release of Ach. Consequently, the CMAP increases, a process called facilitation [19].

In this study, no significant difference was recorded in the TAMS measuring shoulder extension and external rotation, and wrist extension between the two groups A and B. The reason for such an outcome can be based on the grounds that, for shoulder extension, the deltoid muscle's posterior fibers are aided by other powerful prime movers that were not involved in the injury. They are pectoralis major, latissimus dorsi and the teres major [20]. It should be noted that the taping technique addressed the anterior and posterior fibers of the deltoid, which is why there was no significant difference in shoulder external rotation since the prime mover for this action is the

infraspinatus [20], which although affected, was not addressed in the taping procedure. As for wrist extension, the kinesiotope was not applied over the forearm to address the wrist extensor muscles; instead it was applied in a manner to enhance supination of the forearm.

The kinesiotope idea is still rising in the medical field and it has numerous advantages over the functional system of the body. Kinesiotope as an adjunct to the therapeutic procedures can improve strength, functional activities, proprioception, control, and positioning. It also can decrease pain by being placed in different places with techniques and tension [8,21,22]. It is a technique that allows a therapist to work on more functional activities through improved proper alignment but with the tape acting as an extra hand. We compared for the first time, to our knowledge, the use of kinesiotope in patients with Erb's palsy for addressing the problem of Erb's Engram. This present study provided the effect of applying kinesiotope over the deltoid and the forearm, together with a physical therapy program, on the development of proper upper extremity function in children recovering from Erb's palsy.

The use of kinesiotope is fairly new to the pediatric world but is showing progress with tone and strength in multiple diagnoses. New studies are emerging proving the positive effect kinesiotope has over improving upper extremity control and function in acute pediatric rehabilitation clinics and was beneficial in addition to occupational therapy programs during hospitalization [23]. Based on this concept, kinesiotope fastens motor learning process, avoids using compensatory patterns and confirms child's normal movement patterns daily using, facilitated by a physiotherapist or parents [24].

Regarding balance, kinesiotope was beneficial in patients with a diagnosis of myelomeningocele and it was verified to be used clinically in children with poor sitting balance, weak body muscles and balance problems on body muscles in addition to physiotherapy and rehabilitation [25].

Nerve injuries, being a main subject in this study, have had its share in studies confirming the effectiveness of kinesiotope in their rehabilitative program. Kinesiotope with exercise cancelled reconstructive surgery in a 2-year-old female and made a significant difference in the child's upper extremity function [26]. In a different study on peroneus nerve injury, therapy revealed improvement of the symmetry of movement, stabilization of the tarsal joint, a significant increase of the foot and toes mobility, the decrease of oedema, decrease of hypaesthesia symptoms and improvement of life quality [27]. Another study on using kinesiotope after facial nerve reconstruction noted improvement in face symmetry, tongue muscles movements and in some elements determining quality of life of the patient [28]. The use of kinesiotope in early rehabilitation after acute ischemic insult of the patients with the leg paresis undoubtedly confirm faster maintenance of balance and walking, which leads to faster functional recovery, stability in walking and climbing the stairs [29]. One must notice that kinesiotope is proven effective when used as adjunct to an exercise or manual therapy programs to achieve the required goals and maximize functional independence with minimal pain [30,31] and that there are no absolute contraindications to the use of kinesiotope as part of comprehensive physiotherapeutic management [32].

The technique by which the tape was applied (from origin to insertion) was chosen to assist and smooth muscle contraction, thus facilitating and improving strength [33]. The biceps and

the deltoid muscles are innervated by nerves originating chiefly in the C5–C6 roots. In the majority of obstetric brachial plexus injuries the injury to C5 is more severe than the other roots (except in cases where the lower roots are avulsed). This means that it typically takes more time to recover muscles innervated by C5 than the other roots. The timeline of biceps and deltoid function recovery is used as an indicator of recovery speed [3]. Therefore, kinesiotope was chosen to be taped over the anterior and posterior deltoid muscle fibers to address the weakness of shoulder flexion, extension, abduction and external rotation, and over the forearm in an upward spiral manner mimicking the plane of movement of the forearm when performing supination. Kinesiotope applied to pediatric patients with neurological impairment should be based on regular and adequate physical therapy assessment procedures and tools, as the changes may occur in motor learning process level and movement patterns in children due to using kinesiotope rapidly and in order to guarantee permanent progress [24].

Limitations of this study were the irregular attendance of the subjects due to illness or vaccinations as a consequence to their young age, the lack of blinding and real randomization. It was practically impossible to carry out blinding as all of the evaluative and therapeutic procedures were executed by the same therapist. As for real randomization, patients were enlisted to this study over the course of one year. In order to achieve equality in assignments of the groups prior to therapy, their values of pretreatment percentages of degeneration of the deltoid and the biceps were entered into a statistical program which determined the group of assignment according to mean of each group while keeping no significant difference between the two groups.

Conclusion

In our series of 30 patients with Erb's palsy, kinesiotope used as an adjunct to a physical therapy program evidenced a better earlier and smoother recovery to the affected arm than using a therapy program alone. It is not known if the enhanced muscular function noted shortly after application of kinesiotope would be sustained after a prolonged period. These and other questions need to be addressed in further research efforts. Until then, we recommend that any physical therapist should encourage early intervention with Erb's palsy or any other type of diagnosis and introduce kinesiotope to his traditional therapy program. We also recommend that they be familiar with the benefits and sorts of tape applications and use the most appropriate type to address the matter he has at hand.

Acknowledgements

The authors would like to thank the Kinesiotope Association, Albuquerque, New Mexico – USA, for kindly supplying the Kinesiotope used for applications in this study.

References

- [1] Wilson P, Kenyon P. Congenital brachial plexus lesion. The newsletter of the children's hospital physical medicine and rehabilitation, vol. 6(3). Denver, Colorado; 2002. p. 1–4.
- [2] Marino BS, Fine KS, McMillan JA. Blue prints pediatrics. 3rd ed. Blackwell Publishing; 2004. p. 163.

- [3] Nath RK. Obstetric brachial plexus injuries, Erb's Palsy, The Nath method of diagnosis and treatment. Texas Nerve and Paralysis Institute; 2006. p. 6–55.
- [4] van der Sluijs JA, van Ouwkerk WJ, de Gast A, Wuisman PI, Nollet F, Manoliu RA. Deformities of the shoulder in infants younger than 12 months with an obstetric lesion of the brachial plexus. *J Bone Joint Surg Br* 2001;83(4):551–5.
- [5] Nath RK, Karicherla P, Mahmoududdin F. Shoulder function and anatomy in complete obstetric brachial plexus palsy: long-term improvement after triangle tilt surgery. *Childs Nerv Syst* 2010;26:1009–19.
- [6] Chen PL, Hong WH, Lin CH, Chen WC. Biomechanics effects of kinesio taping for persons with patellofemoral pain syndrome during stair climbing. In: Abu Osman NA, Ibrahim F, Wan Abas WAB, Abd Rahman HS, Ting HN, editors. *Biomed 2008, Proceedings 21*. Berlin: Springer; 2008. p. 395–7.
- [7] Martin T. The use of kinesio tex tape as an adjunct to treatment for children with brachial plexus injury. *Outreach Magazine of the United Brachial Plexus Network, inc.*, 2005, issue 17:8-10. <<http://www.ubpn.org/Docs/Outreach/SP2005.pdf>> .
- [8] Grisham SR, Deming LM. *Pediatric life care planning and case management*, vol. 180, 2nd ed. Taylor & Francis Group; 2011. p. 520–1.
- [9] Snow JB, Wackym PA. *Ballerg's otorhinolaryngology 17: Head and neck surgery*. Centinal ed. BC Decker Inc.; 2009. p. 403.
- [10] Dumont CE, Forin V, Asfazadourian H, Romana C. Function of the upper limb after surgery for obstetric brachial plexus palsy. *J Bone Joint Surg (Br)* 2001(83-B):894–900.
- [11] Rouse DJ, Owen J, Goldenberg RL, Cliver SP. The Effectiveness and costs of effective cesarean delivery for fetal macrosomia diagnosed by ultrasound. *JAMA* 1996;276:1480–6.
- [12] Ogden JA. *Skeletal injury in the child*, 3rd ed. Springer-Verlag NY Inc.; 2000. p. 445.
- [13] Guha DK. *Guha's neonatology: principles and practice*, vol 1. 3rd ed. Jaypee Brothers Publishers; 2005. p. 473.
- [14] Kulkarni GS. *Textbook of orthopedics and trauma*. 2nd ed. Jaypee Brothers Medical Publishers; 2008. p. 3373.
- [15] Andersen J, Watt J, Olson J, Van Aerde J. Perinatal brachial plexus palsy. *Paediatr Child Health* 2006;11(2):93–100.
- [16] Al Qattan MM. An obstetric brachial plexus data sheet. *J Hand Microsurg* 2009;1(1):32–8.
- [17] Gupte S. *Recent advances in pediatrics-17: hot topics*. Jaypee Brothers medical Publishers; 2007.
- [18] Oh SJ. *Clinical electromyography: nerve conduction studies*, 3rd ed. Lippincott Williams & Wilkins; 2003.
- [19] Sirven JI, Malamut BL. *Clinical neurology of the older adult*, 2nd ed. Lippincott Williams and Wilkins; 2008. p. 430.
- [20] Griffin JC. *Client-centered exercise prescription*, 2nd ed. Human Kinetics; 2006.
- [21] Burt J, White G. *Lymphoedema. A breast cancer patient's guide to prevention and healing*, 2nd ed. Hunter House; 2005.
- [22] Hsu YH, Chen WY, Lin HC, Wang WT, Shih YF. The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. *J Electromyogr Kinesiol* 2009;19(6):1092–9.
- [23] Yasukawa A, Pate P, Sisung C. Pilot study: investigating the effects of kinesio taping in an acute pediatric rehabilitation setting. *Am J Occup Ther* 2006;60(1):104–10.
- [24] Maas H, Koort R, Sander V. The pediatric physical therapy intervention using kinesiotaping in Estonia. *FP* 2007;7(3):355–61.
- [25] Şimşek TT. The effects of kinesio taping on sitting posture and functional independence in children with myelomeningocele: report of four cases. *Turk Arch Ped* 2011;46:177–80.
- [26] Walsh SF. Treatment of a brachial plexus injury using kinesiotape and exercise. *Physiother Theory Pract* 2010;26(7):490–6.
- [27] Kuciel-Lewandowska J, Paprocka-Borowicz M, Kierzek A, Pozowski A, Boerner E. The use of kinesiotaping in the after trauma therapy of damaged peroneus nerve – case description 3. *Acta Bio-Optica Inform Med* 2008;14(3):224–5.
- [28] Haas I, Senderek T, Krupa L. The use of kinesio taping in improvement of face mobility in patient after facial nerve reconstruction. *FP* 2005;5(2):272–6.
- [29] Nikcević L, Plavšić A, Mujoviić N, Hrkloviić M, Brdareski Z, Konstantinoviić L, et al. Application of kinesio taping on the patients with leg paresis and recurvatum after acute ischemic insult. *Eur J Phys Rehab Med* 2010;46(Suppl. 1/2):33.
- [30] Wilson WC, Grande CM, Hayt DB. *Trauma Critical Care. Inform Healthcare* 2007;2:1195.
- [31] Paoloni M, Bernetti A, Fratocchi G, Mangone M, Parrinello L, Del Pilar Cooper M, et al. Kinesiotaping applied to lumbar muscles influences clinical and electromyographic characteristics in chronic low back pain patients. *Eur J Phys Rehab Med* 2011;47(2):237–44.
- [32] Śliwiński Z, Halat B, Kufel W, Michalak B, Kiljański M. The effect of kinesio taping applications on motor activity in children with developmental defects. *FP* 2007;7(1):52–62.
- [33] McGee S. *Tennis fitness for the love of it. A mindful approach to fitness for injury-free tennis*. Zuzi Publishing; 2010, 29–30.