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Effect of Supination Splint onUpper Extremity Function in Children with Erb'sPalsy

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ABSTRACT

Background: The residual movements after a brachial plexus injury canbe used to perform desired tasks with the help of a variety of devices.**Objective:**The aim of this study was to investigate the effect ofsupination splintonupper limb functionin children with Erb's Palsy. **Methods:**Thirty children with Erb's Palsyfrom both sexes ranging in age from 4to 6 years were assigned into two groups of equal number. The control group received a specially designed exercise program and the study group received supination splint in addition to the same exercise program. The arm function was evaluated by the Mallet score system, while activeshoulderflexion abduction and external rotation and forearm supination range of motion(ROM) were measured by electrogoniometer. **Results:**A significant improvement was observed in measured variables of the two groups when comparing their pre and post treatment mean values. A significant difference was also observed when comparing the post treatment results of the two groups.Increases in ROM of shoulder flexion,abduction,external rotation and forearm supination were 3.95% (p = 0.015),22.8% (p = 0.04), 45.620% (p = 0.023) and 14.75% (p = 0.04)greater, respectively, in the study group compared with the control group . Regarding Mallet system scores,increases in shoulder abduction,external rotation ,hand to neck,hand to spine and hand to mouthwere 14.02% (p= 0.011) ,27.48% (p = 0.022), 37.15% (p= 0.014) ,30.05% (p= 0.032)and 26.69% (p= 0.01)greater, respectively, in the study group compared with the control group .**Conclusion:**The supination splint is an effective method for improving the upper limb function in children with Erb's Palsy.

Keywords:*Erb's Palsy; supination splint;upper extremity function*

INTRODUCTION

The brachial plexus provides the nerve supply to the upper limb, from roots C5 to T1. Obstetrical brachial plexus paralysis (OBPP) refers to injury noted in the perinatal period to all or a portion of the brachial plexus [1, 2].

Obstetrical brachial plexus paralysis occur in 0.5-5 infants per 1000 live births3,4.The incidence ranges globally from 0.2-4% of live births. According to the World Health Organization, prevalence is generally 1-2% worldwide, with the higher numbers being in underdeveloped countries [5].

Erb's palsy occurs from stretching of the fifth and sixth cervical nerves. The infant's arm is held in "Waiter's tip" position, where the arm is extended and internally rotated and the wrist is flexed 6. When there is an absent Moro reflex in the arm with intact hand grip,Erb's palsy should be suspected7. Although spontaneous recovery may occur in some patients,contractures and deformities may occur rapidly. One should not wait spontaneous recovery, as limitation of motion and deformity may continue, in spite of complete return of muscle power, if therapy is delayed [8].

An Erb'sengram develops in recovering Erb's palsied children limiting their upper extremity function. It's caused by an asymmetric injury at a time of rapid limb growth and an asymmetric reinnervation of muscles causing muscle imbalances in the shoulder that will virtually lead to bone deformations [9]. Furthermore, scapular growth is impaired compared to the normal side [10].

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 abnormal 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 [11].

Forearm rotation is necessary for various daily activities, such as feeding, dressing, and personalhygiene. It is also an integral component of motion for many vocations and avocations [12].Normal forearm rotation is approximately 0° to 80° or90° for supination and pronation1 [3]. A functional arc offorearm rotation is 100° (50° of supination and50°of pronation) [14,15]. Although the loss of pronation canbe compensated by shoulder abduction [16], nodegree of shoulder or elbow compensation canrestore function when there is a significant loss offorearm supination [17].

Splints to restore function have been widely used by therapists for many years to prevent stress deprivation in ligaments, joints, and muscle tissue [18].Understanding thephysical mechanical properties of both loose anddense connective tissue is essential for the application of splints. Stress application that iscontrolled and graded to all types of connectivetissue can restore functional length and avoid an undesirable inflammatory response. One ofthe most common clinical problems is adaptive shortening/remodeling of the muscles [19]. This is a change in fiber length that, along with a decreasein cross-sectional area, will greatly diminish the power potential of muscle [19] andimpacts the ability of the muscle to produce force [20,21].

As forearm movement into supination is essential in positioning the hand for function. Thus, it would be of huge benefit to develop a splint that incorporates forearm movement as well as wrist and thumb movement [22].

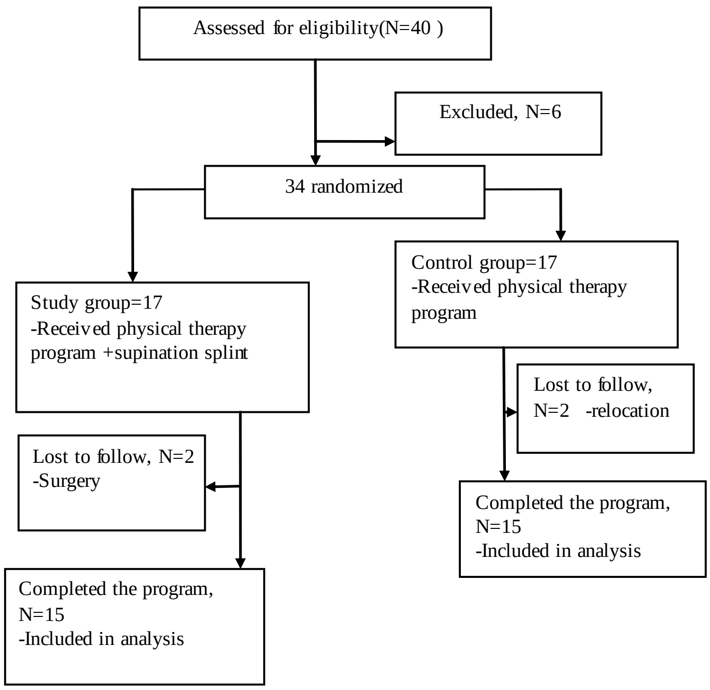
The researcher felt that if a splint was designed to encourage forearm movement, perhaps children with Erb'spalsywould be able to participate more fully in their daily activities,therefore; the purpose of this study was to investigate the effect of supination splintonupper limb function in children with Erb's palsy.

METHODS

This study was approved by the Hospital of MedicalRehabilitation, AlmadinahAlmonawara,Kingdom of Saudi Arabia. Written consent was taken from parents or caregivers prior to enrolment for the study. Thirty children from both sexes were selected. The inclusion criteria were as follows:a)age group between 4 to 6 years,b)the subjects had a confirmed medical diagnosis by a specialist physician in the form of Erb's type (C5–6) injuries,c)second and third degrees ofnerve severance according to Sunderland classification for nerve injuries [23],d)normal intelligence quotient range(4-6 years).Exclusion criteriawere: a) associated problems like mental retardation, b) epilepsy,c) any recent surgical procedure for correction of deformity in upper extremity,d) serious or recurring medical complications according to the medical report signed by their physician,e)fixed contractures or stiffness in the affected upper extremity that would limit activity engagement.During the study, children were not receiving other interventions to improve the upper extremity (UE) function.

Subjects were divided randomly into two groups of equal number(Figure1). Following the baseline evaluation of each child, a closed envelope was randomly selected that contained the child's group allocation. The treatment allocation was disclosed to the child and the parents or caregiversimmediately after the baseline evaluation. The control group received physical therapy exercise program focused on improving arm function as well as shoulder flexion, abduction,external rotationand forearm supination. The study group received supination splint in addition to the same exercise program given to the control group.

Figure .1:Flow chart of participation throughout the study



N: number

(A) Materials for evaluation

1) Electrogoniometer (Biometrics, Model SG150) was used to determine the range of motion of the shoulder flexion, abduction, and external rotation and forearm supination. It is a tool used to eliminate the need to manually score each measurement by storing the information internally. It has a range of 0° to 360° and is accurate to +/- 1. The validity and reliability of electrogoniometer for measurement of joint range of motion was tested and well documented [24].

2) Mallet scale system (All participants were assessed pre-treatment and after 12 successive weeks of treatment using standardized movements of Mallet scale to index active shoulder movements [25].

(B)Materials for treatment

1) Physical therapy Equipments(as hot packs, gymnastic mats, wedges,ball,balance board and rolls) were used in conducting the physical therapy program.

2) Supination splint helps to increase forearm range of motion in persons with orthopedic soft-tissue injuries and persons with neurological disorders such as stroke, CP or brachial plexus injuries. It consists of two parts:1)thumb web-space glove which is made of 1/8 inches (3.2mm) loop neoprene with hook and loop fasteners,2)strap which is 2 inches (5.1cm) wide spiral forearm strap. The strap supplies a dynamic force to mobilize the forearm into greater supination. By wrapping it spirally around the forearm, the strap applies a prolonged, gentle pull on the forearm into the desired motion in a comfortable manner. The wrist and hand remain free to move.

(A) Methods for evaluation

1) Mallet scale system, all participants were assessed pre-treatment and after 12 successive weeks of treatment by evaluating video recordings of standardized movements of Mallet scale to evaluate active shoulder movements [26]. This scale assesses the function of the shoulder, and it is based on five criteria: The ability to actively abduct the arm, the ability to externally rotate the arm, the ability to place the hand behind the neck as well as behind the back or spine, and the ability to place the hand over the mouth. A total Mallet score is calculated from the scores gained in the performance of the former tasks with a grading scale of I–V giving a maximum score of 25. This system can only be used with a cooperative, older child. Mallet scale is a reliable method for evaluating children with OBPP based on the ability to perform functional positioning of the affected limb [27]. All evaluations were conducted by trained therapists who were blind to which group the child belonged.

2) Electro goniometer, for assessment of ROM. The electrogoniometer was calibrated before measurement at 0°.Shoulder flexion, abduction and external rotation and forearm supination were determined for each patient from supine lying position.

(B)Methods for treatment

1) Control group:Aspecially designed physical therapy program was applied one hour, three times per week, for three successive months(appendix1).

The parents or caregivers were trained to carry out the training program at home for 30 minutes,6times weekly. A number of measures had been taken to assure the proper performance of the therapeutic program at home in a satisfactory manner. 1) A written list of training tasks was drawn up for the caregiver to carry out at home. 2) The caregiver kept a diary of what was actually done to be revised by therapist at the next session at clinic. 3) Monitoring of compliance by the caregivers with the instructed home routine by a daily phone.

2) The study group: Children in this group received the same exercise program given to the control group,in addition to supination splint,(Figure 2).Parents were instructed to put the supination splint atleast four hours per day and 8hours per night. Thetechnique for applying the splint was simplified and explained to the parents as follow: using mild cream,the parents needed to applyvery gentle pressure to the upper limb when doing massage and the gentle stretch to the pronator muscles. The home program was presented to the parents in a handout format that contained written and pictorial information on:1)massage,2)stretch exercise,3)splint application,4)splint wearing regim,5)instructions for caring and wearing the splint and6)precautions necessary when applying the splint.

Fig.2: supination splint application

Statistical analysis

The collected data from this study represent the statistical analysis of the shoulder active flexion,abduction and external rotation and forearm supination ROM (in degrees)andMallet score system measured pre and post three months of treatment for bothgroups. The raw data of the ROM were statistically treated to determine the mean and standard deviation for the two groups and the student t-test was then applied to examine the significance of the treatment conducted for each group. The raw data of the Mallet system were statistically treated by non-parametric statistics: Wilcoxon test to compare mean values between pre and post treatment in each group and Mann–Whitney test to compare mean values between the two groups.

RESULTS

The obtained results in this study revealed no significant differences when comparing the pre-treatment mean values of both groups. There was a significant improvement in the ROM of shoulder flexion, abduction external rotation and forearm supination post treatment in the two groups as shown in table (1)and Fig.(3). Increases in ROM of shoulder flexion, abduction, external rotation and forearm supination were 3.95% ($p = 0.015$) ,22.8% ($p = 0.04$), 45.620% ($p = 0.023$) and 14.75% ($p = 0.04$)greater, respectively, in the study group compared with the control group .This means that there was a significant improvement in favor of the study group when comparing the post treatment mean values of the ROM of the two groups.

Table 1:Comparison between pre and post intervention for each group forshoulder flexion, abduction, external rotation andforearm supination ROM.

Variable	Patient' s group	Mean± SD		t-value	p-value
		Pre	Post		
Shoulder flexion	Control	69.866±0.11	76.666±1.29	-13.61	0.013*
	Study	70.33±1.838	80.066±3.104	-19.38	0.001*
Shoulder abduction	Control	68.3±9.1	90.41±8.98	-16.253	0.000*
	Study	70.21±9.36	108.49±13.1	-23.8	0.000*
Shoulder ext. rot.	Control	36.12±4.17	52.98±4.83	-13.11	0.000*
	Study	35.07±5.99	67.44±5.93	-29.97	0.000*
Forearm supination	Control	42.533±2.263	45.800±1.52	-4.847	0.005*
	Study	42.800±1.971	52.400±1.404	-14.379	0.003*

P-value: probability value, *:significant, Ext.rot.: external rotation

Significant improvement was observed in all the measured variables of the two groups, when comparing their pre and post-treatment mean values of the Mallet score system as shown in Table (2) and Fig. (4).After treatment a significant difference was observed when comparing the post-treatment results of the two groups in favor of the study group(B).

Fig. 3:Comparison between pre and post intervention for each group forshoulder flexion, abduction, external rotation andforearm supination ROM.

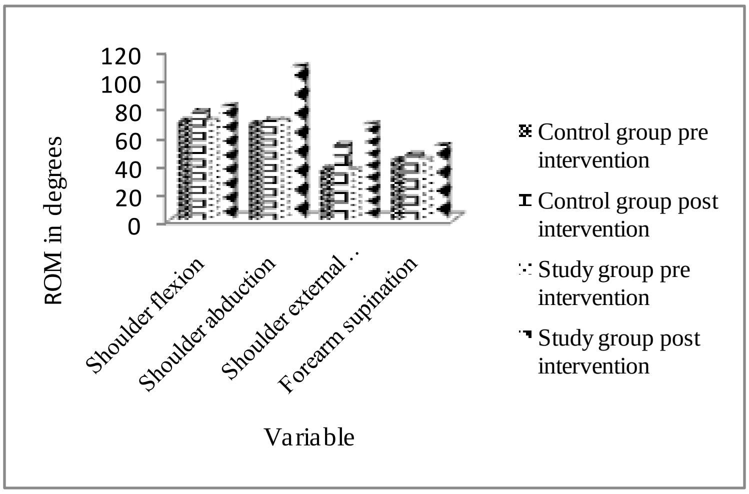


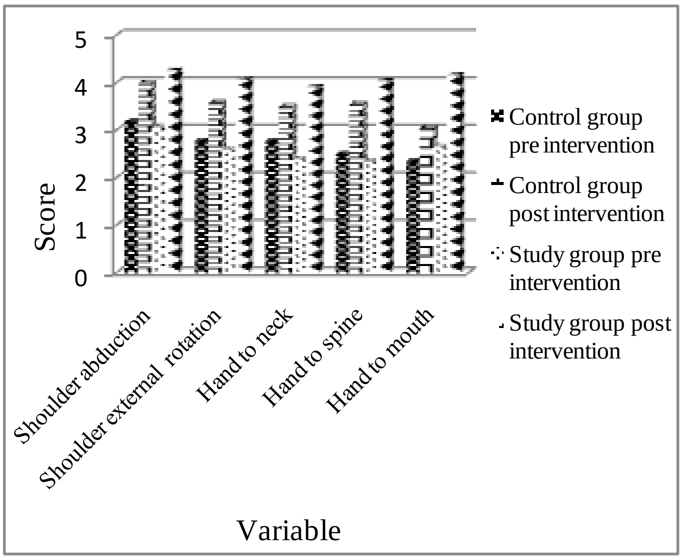
Table 2:Comparison between pre and post intervention for each group forMallet system scores(Mean±SD).

Variable	Patient's group	Mean± SD		Z-value	P-value
		Pre	Post		
Abduction	Control	3.17±0.51	3.98±0.59	-2.998	0.002*
	Study	3.045±0.49	4.25±0.395	-3.544	0.001*
External rotation	Control	2.77±0.6	3.57±0.68	3.214	0.004*
	Study	2.596±0.39	4.059±0.34	-3.149	0.001*
Hand to neck	Control	2.77±0.88	3.49±1.19	-2.794	0.005*
	Study	2.39±0.44	3.899±0.49	-3.594	0.000*
Handto spine	Control	2.49±0.66	3.54±0.7	-3.735	0.001*
	Study	2.34±0.4	4.03±0.29	-3.549	0.000*
Handto mouth	Control	2.34±0.49	3.04±0.5	-3.142	0.003*
	Study	2.65±0.61	4.15±0.43	-3.219	0.001*

P-value: probability value *:significant

Increases in shoulder abduction, external rotation, hand to neck, hand to spine and hand to mouth were 14.02% (p= 0.011) ,27.48% (p = 0.022), 37.15% (p= 0.014) ,30.05% (p= 0.032)and 26.69% (p= 0.01)greater, respectively, in the study group compared with the control group.

Fig. 4: Comparison between pre and post intervention for each group for Mallet system scores.



DISCUSSION

The improvement obtained in both groups could be explained by facilitating motor skill learning via the course of training for 12 successive weeks .It was directed to enhance affected arm function as well as shoulder flexion, abduction and external rotation and forearm supination ROM. The designed exercise program provided the opportunities for participants to practice involved upper limb movement in different situations with different purposeful and meaningful type of exercises that augment the process of motor learning.

The improvement observed in the study group may be explained by theeffect of supination splint on muscle extensibility this come in agreement withLieber et al.[28]andKohand Herzog [29] who stated thatphysical therapy interventions often are used to restorenormal mobility, and physical therapists use a variety oftechniques, such as passive range of motion, stretchingby the therapist or by the patient, splinting, and serialcasting. The underlying mechanism of using stretching techniques is that itincreases muscular extensibility which,in turn,improves ROM [30-36].

Also the improvement in the study group may be explained by the effect of splint on neural plasticity; the brain homunculus contains a total bodymap for both a sensory and motor tract, and eachbody part is represented based upon percentageof use with functional tasks[37].The cortical maps can change with functional use and has a highdegree of plasticity [38].Hand and upper extremity disuse can createmany pitfalls resulting from a decrease of sensory-motor input and stress deprivation of connectivetissue [39].Patients may develop fear and depressionwith a loss of social roles and a decrease inactivities of daily living (ADL) skills. Suchpatients often complain of an increase in painreflex with a change in muscle-tendon length andfibrotic change in joint capsules and ligamentousstructures. Muscle fiber type can change withdisuse from slow twitch to fast twitch. Atrophyof muscle cross-sectional area can occur and limitforce potential with ADL activities [40].

The improvement in the study group may also be due to correction of Erb'sengram(flexion of the elbow accompanied by abduction of shoulder) [41] which occur as a result of muscle imbalances and bony deformities that occur because the denervated muscles do not grow at the same rate as their functional, opposing muscles [42]. Kulkarni [43] stated that correction of the supination deformity requires early intervention.

The design and biomechanics of the supination splint allowed for a constant but gradual force to be applied to the pronator muscles.According to Tardieu et al. [44]and Wilton [45] muscles fibers can be lengthened if muscles are gradually stretched and maintained in a balanced state. Gradual multi-step muscle lengthening is less invasive than single-step lengthening and increasessarcomere number (sarcomerogenesis) [46].

The supination splint provided the subjects with the opportunity to actively move their upper limb,while it simultaneously stretched the muscles gradually and increased the ROM,thereby facilitating participation in functional tasks [22].This active participation facilitated the process of motor learning whichcomes in agreement with Kantak et al. [47] who stated that an important aspect to motor learning is active participation, in order for learning to occur the child must be actively engaged in the task. This is done by presenting the child with a task that forces them to plan and execute purposeful, goal directed movement.

This study was limited to [30] children who were selected from the pediatricsout-patient clinicofthe Hospital of Medical Rehabilitation,AlmadinahAlmonawara,Saudi Arabia.

On the basis of the findings of this study, weadvise: the use of supination splint on different age groups of children with Erb's palsy.Further research should be done to investigate the effect of increasing period of treatment on upper limb function, using more objective evaluative tools as electromyography to record muscular activity during wearing the supination splint andcomparative studies are needed to investigate the effect of supination splint on other types of pediatric disorders as hemiplegic cerebral palsy.

CONCLUSION

From the obtained results of this study it can be concluded that the supination splint is effective in improving upper limb functions in children with Erb's palsy.

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APPENDIX 1

Table 3: Physical Therapy program given to both groups

Exercise	Time
1- Moist heat in the form of hot packs	10min.
2-Massage (thumb effleurage and spiral massage) starting from the distal part (hand) to the proximal one (shoulder and periscapular area)	9min.
3-Arm reaching exercises toward target and finger ladder exercise	5 min.
4-Wall bar exercise and pulling trolleys in play.	4 min.
5-Rest	2 min.
6-Arm–Hand exercises as: throwing ball toward target from standing position either above or below the head level.	5 min.
7-Bouncing ball from standing position and catching ball thrown from different directions during standing or catching bounced ball.	5 min.
8-Postural reaction exercises that included protective extensor thrust in different directions from sitting on roll and equilibrium reaction from sitting on ball or standing on balance board.	5min.
9-Upper limb self-dependent exercises included: eating with a spoon, picking up and feeding self-sandwich, drinking from cup, wear and turning off shirt, combing hair, brushing teeth, washing face by hands, placing hat on head and wiping nose or face.	10min.
10-Stretching 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.	5 min.

الملخص العربي

دراسة تأثير جبيرة استلقاءالساعد على وظيفة الطرف العلوى للأطفال المصابين بالشلل الاربى

هدف البحث: - دراسة تأثير جبيرةاستلقاء الساعد على وظيفة الطرف العلوى للأطفال المصابين بالشلل الإربى.**تصميم البحث: -** برنامج علاجى باستخدام جبيرة استلقاءالساعد للأطفال المصابين بالشلل الاربى. **مقاييس النتائج الرئيسية: -** التشخيص المحال به المرضى مقابل التشخيص الفعلي بعد فحصهم. **طريقة البحث: -** تم اختيار 30 طفلا من المصابين بالشلل الإربى تتراوح اعمارهم من 4 الى 6 سنواتوتم تقسيمهم الى مجموعتين مجموعة ضابطة والتى تلقت مجموعة من التمارين لمدة ثلاث شهور بواقع ثلاث جلسات أسبوعيا بينما تلقت مجموعة الدراسة نفس البرنامج العلاجى بالاضافة الى جبيرة الساعد. **النتائج: -** أظهرتالنتائجوجود فروق ذات دلالة احصائية بالنسبة للمجموعتين عند مقارنة نتائج ما قبل وبعد العلاج كما أظهرت النتائج وجود فروق ذات دلالة إحصائية عند مقارنة نتائج ما بعد العلاج للمجموعتين لصالح مجموعة الدراسة **.الخلاصة:-** يمكن استخدام جبيرة الساعد لتحسين وظيفة الطرف العلوي للأطفال المصابين بالشلل الإربى

مفتاح كلمات البحث:- الشلل الإربى،جبيرة استلقاء الساعد، وظيفة الطرف العلوى.