Purposive Mobilization Exercises to Improve Range of Motion of Children with Second Degree of Shoulder Burn

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Abstract: **Background:** Childhood burns in Egypt are a significant problem, especially in families of low socioeconomic status. The burn injury is related to the loss of normal tissue and its replacement with scar tissue; leading to limitation of movement and disfigurement. Therefore, medical and nursing professionals are working together to avoid loss of range of motion (ROM) of the burnt extremity especially in shoulder as an important organ for children in everyday academic, play and domestic accomplishments, it is also used to express body language and message of communication and needs. **Aim:** This study aimed to assess the effectiveness of applying active and passive mobilization exercises for children with second degree of burn shoulder on improving range of motion. **Design:** A quasi-experimental design with pre/post control group was used. **Subjects and Methods:** A purposive sample of 90 children aged 5-15 years with second-degree burnt shoulder were classified into an experimental group who were exposed to the mobilization exercises (n=50), and a control group (n=40) who were not administered to the study intervention. All angles of movements were measured using a goniometer properly; including wrist flexion (palmar), wrist extension (dorsiflexion), wrist radial deviation, wrist ulnar deviation, metacarpophalangeal joints (MCP)-finger flexion, MCP-finger extension, MCP-finger abduction, MCP-finger adduction, forearm supination, forearm pronation, elbow flexion, shoulder flexion, and shoulder extension. **Results and Conclusions:** Findings concluded that at the completion of the four sessions of intervention, subjects in the study group had gained the best percent improvement in the mean angle degrees of the elbow flexion (54.2±15.3) and wrist ulnar deviation increased to 52.8±10.4. In contrast, results did not show any progress in ROM angles among burnt children of the control group even at the third or fourth day, especially in the wrist flexion that reached minimum change (4.6±4.5) and MCP-finger flexion (7.8±6.3) at the fourth day. **Recommendations:** Based on the study findings, it is recommended that well-trained nurses should apply mobilization exercises at burn units. Further studies are needed to establish the long-term outcome for the burnt children for evaluating the effect of mobilization exercises on ‘‘new’’ versus ‘‘old’’ burn scar. More researches are needed to explore the benefits of repeated treatments of mobilization exercises on patients with a larger sample that could verify this positive trend.

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Introduction:

Childhood burns in Egypt are a significant problem, especially in families of low socioeconomic status. These families live in overcrowded accommodations, and tend to neglect their children and use outdated stoves or kerosene ones, with insufficient safety measures (El-Badawy & Mabrouk, 1998; Omar *et al.*, 2004). Survivors of burns often lead a life complicated not only by the physical consequences of the burns, but also by stigma and discrimination related to the disability and disfigurement of the involved limb (World Health Organization, 2008). Moreover, the shoulder involvement is more serious because late effects of burn injury are related to the loss of normal tissue and its replacement with scar tissue; leading to limitation of movement, disfigurement and social embarrassment (Shelley & Dziewulski, 2006).

Burns have some consequences such as long lasting hypertrophic scarring, contractures, and keloid formation of a limb (Potts & Mandleco, 2011). There is no doubt that the risk increases significantly when hypertrophic scars have a high blood flow and increased levels of collagen which are extremely active and becomes raised, red and rigid. Moreover, these scars tend to have a high rate of contraction and have other symptoms including dryness and lack of pliability; however, several weeks later. If corrective measures are not taken to oppose the contractile force of the scar, scar contracture occurs and range of motion (ROM) is lost (Procter, 2010).

Goals of purposive mobilization exercises are to promote functional movements through facilitation and relaxation of muscle groups to gain newly ROM. In addition to increase and strengthen the muscles contractions with properly graded resistance which is adjusted to fit the needs of each patient (Adler *et al.*, 2008). In this context, Morian *et al.* (2008) suggested purposive exercises as an intense nursing intervention resulted in increased ROM and decreased pain of the patient's affected limb when the burn occurs near or over a joint and the injury causing typically limited range of motion.

When burn occurs to the flexor aspect of a joint or limb, the risk of contracture is greater, that is because the flexor muscles are generally stronger than the extensors. The flexed position means the position of function; for example clasping the hand, flexing the metacarpo-phalygeal (MCP), bending the elbow, forward and flexion of the shoulder. Therefore, aims of anti-contracture purposive exercises are to counteract this natural tendency towards flexion (Procter, 2010). For this reason, nurses should demonstrate the child and family to apply the purposive mobilization exercises and provide them with oral and written instructions, and discuss about the expected outcomes (Moss, 2010).

Children can be supported and encouraged to participate in active range of motion exercises, which performed by the patient under the supervision of the nurse; otherwise, those children would require passive exercises which performed by the nurse, or with the nurse helping if the patient cannot do those exercises independently (Smeltzer *et al.*, 2010; Potts & Mandleco, 2011). Therefore, medical and nursing professionals are working together to avoid loss of ROM of the burnt shoulder and to prevent contracture developing, especially in the early stages of post-burn healing scars and if the burn is close to or over a joint; which is extremely active and the contractile force is at its highest (Procter, 2010).

In this study, an effort is being made to apply active and passive mobilization techniques as essential interventions to reach best help for burnt children towards improving range of motion measurement of the involved joints among children survivors with second degree of shoulder burn.

Aim

This study aimed to assess the effectiveness of applying active and passive mobilization exercises in children with second degree of burn shoulder on improving range of motion.

Hypothesis

The study hypothesized that providing purposeful mobilization exercises would achieve possible improvement in range of motion of the children's affected limb with second degree of shoulder burn.

Subjects and Methods

Design

A quasi-experimental design with pre/post control group was used.

Setting

The study was conducted at the Burn Unit and the Outpatient Burn Clinic, in Ain Shams University Hospital, Cairo, Egypt. The Burn Unit consists of four rooms with thirteen beds in which patients are hospitalized for treatment and rehabilitation.

Subjects

A purposive sample of 90 children aged 5-15 years with second-degree burnt shoulder were enrolled in this study. Fifty children were in the study group, and other forty-burnt children participated as a control group.

Burnt children were excluded if mobilization exercises or any other exercises were administered as a part of, or in a combination with, any other therapy purpose or if they developed infection. Children with concomitant burn such as electrical, chemical, or explosion; in addition to children who decided or did not wish to take part in the study, were also excluded.

Ninety-eight participants were identified, of which only 90 met the criteria for inclusion. The mean age of participants in the study group was 9.8±4.1 years, whereas children in the control group aged 10.0±4.3 years and come usually from the lower socioeconomic strata.

The inclusion criteria were: (a) 5 years or older, (b) diagnosis of second-degree burns (partial- or full-thickness); of wrist, MCP-fingers, forearm, elbow and/or shoulder, (c) burns due to thermal burns (open fire, hot oil or hot water), (d) duration of burn is more than 3 days (with the first injury dressing), and (e) agreement to participate.

Data Collection

The researchers designed and used two different tools, which included a questionnaire about personal and burn characteristics of patients in the study and control groups) and baseline assessment checklists pre/post format include a range of motion assessment chart and physiological assessment.

Structured Questionnaire Sheet

Sociodemographic data.

Characteristics of the children such as: age, gender and level of education.

In addition, data about duration of burn days; burnt region: wrist, MCP, forearm, elbow and shoulder; cause of burn: fire, electric, chemical, road accident, hot liquid or other; depth and degree; medical record number and diagnosis were assessed.

Exploratory phase: All participants were examined by the researchers who assessed their burn degree using the physical examinations and physical records before the intervention.

Range of Motion Measurement Chart

This chart includes the name of joint, position, measurement of the shoulder-joint ROM in degrees and if it is right or left, in addition to the time and day at Day 1, Day 2, Day 3 and Day 4.

Angles of movements were measured using a goniometer properly; including wrist flexion (palmar), wrist extension (dorsiflexion), wrist radial deviation, wrist ulnar deviation, MCP-finger flexion, MCP-finger extension, MCP-finger abduction, MCP-finger adduction, forearm supination, forearm pronation, elbow flexion, shoulder flexion, and shoulder extension. The mentioned movements could be tested actively and/or positively (Iyer, 2011).

Physiological Assessment

Assessment of temperature, heart rate (HR) and respiratory rate (RR) were measured for each child to detect any instability that guide as an early onset of infection.

Implementation of Mobilization Exercises

Sessions of mobilization exercises were offered once a day at the same time, between 9:00 a.m. and 2:00 p.m. daily, for a total of 4 days in the period between February and September 2012. Each child had four sessions; which started with a simple introduction about objectives and demonstrations of mobilization technique. Specifically, intervention began slowly depending on the child's pain tolerance and level of comfort.

Some children developed history of fear from touch in reaction to the initial trauma, and from sequential of painful therapeutic and surgical procedures, and the long hospitalization. When those children showed crying, facial grimacing or body movements as fear reactions of the first touch; the researchers alternated the intervention from the passive mobilization exercises and encouraged children to the active technique. Active mobilization exercises were applied to 28% of children, whereas 72% of them were passively mobilized. Briefly, children were afraid from exercises because burns cause the skin to become tight, so that children were instructed for deep breathing with expanding chest as much as possible and to let the air out slowly for relaxing them.

Purposive passive mobilizing exercises started by helping the child to be in a comfortable supine position with arms at sides and knees extended. Patient could stand or sit on a chair without arms. The researchers explained the patient about the difference between pain and a mobilization sensation, and asked the child to vocalize when there was feeling pain. Then, moving of the affected joint as the patient's condition permits, i.e. to the point of resistance or when the child felt pain. When a movement became painful, the researchers stopped advancing the exercise and hold at that position for almost 10-30 seconds according to the patient's pain tolerance. Children with more than one joint burn of the affected shoulder were given a break for 5 minutes before continuing the exercises for 15 to 20 minutes per each burnt joint.

Starting purposive active mobilizing exercises for children who were older and more cooperative, by asking them to hold his/her arm straight down at side and face palms in toward the body. From this position, the child was demonstrated to bend the wrist up and down as far as possible; this test intended the (wrist flexion and wrist extension). Next, the child was asked to move the hand from side to side; to examine the (wrist-radial deviation and wrist-ulnar deviation). Clenching a hand into a fist followed by a straightening movement was done to evaluate the (MCP-finger flexion and MCP-finger extension). Subsequently, spreading the digits apart and closing them together refers to (MCP-finger abduction and MCP-finger adduction). Alternately, children were asked to bend the burnt elbow (elbow flexion); and to make supination and pronation exercises of the forearm, then move the injured shoulder up and down (shoulder flexion and shoulder extension). All angles of movements were measured by the goniometer including wrist, MCP, forearm, elbow and shoulder before and after the mobilization exercises intervention.

Children should not complain of any discomfort during the study intervention. Therefore, we instructed each child to relax as fully as possible, and an attempt was made to maintain eye-to-eye contact with the child during the procedure; because the child's cooperation is important to reach a good fear tolerance and level of comfort.

Evaluation of range of motion (ROM):

The target outcome of this study focused on appraisal of ROM reproducible measurements which can help determine the effectiveness of mobilization exercises on ROM of the burnt shoulder and whether it is getting better, worse or no change throughout the study intervention.

Proper ROM measurements included data about the involved joint, active or passive movement, types of ROM, testing position, equipment used, and the ROM measurement in degrees (Magee, 2008).

The child was positioned for measuring the ROM of the affected extremity by using standard geniometer in degrees. It is a plastic baseline 180-degree universal goniometer for estimating the flexibility by measuring the ROM in a joint.

Normally, average values of ROM in neutral position of joints for the normal child are: Wrist flexion (palmar) (60°), wrist extension (dorsiflexion) (70°), wrist radial deviation (20°), wrist ulnar deviation (30°), MCP-finger flexion (90°), MCP-finger extension (30°), MCP-finger abduction (20°), MCP-finger adduction (20°), forearm supination

(85°), forearm pronation (80°), elbow flexion (140°). In addition, normal movement is about (90°) for shoulder flexion and (45°) for shoulder extension (Luttgens & Hamilton, 1997; Iyer, 2011).

Validity and reliability.

During the program construction phase, the content of media about mobilization technique was provided for children based on the identified objectives and physical and emotional needs of participants in addition to reviewing related literature (e.g., Moore *et al.*, 2009; Ball *et al.*, 2010; Smeltzer *et al.*, 2010; and Potts & Mandleco, 2011). Additionally, the researchers reviewed the modalities of the intervention technique and the length of intervention session with specialists and the clinical expertise in burnt pediatric- patients. Horger (1990) and Hayes *et al.* (2001) verified the reliability of five methods for assessing shoulder ROM and the reliability of goniometric measurements of active and passive wrist motions. Specifically, using goniometer measurements (in degrees), they found high intra-rater reliability and high inter-rater reliability for shoulder measurement (Walker-Bone *et al.,* 2003).

Pilot study:

A pilot study was carried out primarily to make sure if the measurements of the ROM of the injured shoulder by using standard geniometer were associated with acceptably of errors. Modifications were done regarding duration of mobility exercises sessions needed to increase the flexibility of the involved joint. Time needed for the joint to return to the almost pre-burn function level was estimated.

Ethical considerations:

Requests for permission to implement the study were addressed to the Manager of the hospital, and the Chairperson of the burn unit, Ain Shams University. The same procedures were applied to all children after obtaining informed consent/assent from them. All participants had received a verbal explanation of the objectives and process of the study. Children also gave a verbal agreement before each session to receive mobilization exercises.

Statistical analysis:

A Mann Whitney test was conducted to explore differences in ROM movements of wrist, MCP, forearm, elbow, and shoulders' joints among children in the study and control groups throughout the days of follow-up; starting from the initiation of mobilization exercises (Day 1) till the last session (Day 4). All analyses were computed using SPSS 18 version, results were deemed significant when $p<0.05$. Values of percent changes of day 2; day 3 and day 4 were compared to average ROM of day 1 of the study intervention; these differences in angles indicated the progress of joint movements, which were calculated as follows:

Percent change of Day 2 to Day 1 =
100 x (day 2 angle – day 1 angle) / day 1 angle.
Percent change of Day 3 to Day 1=
100 x (day 3 angle – day 1 angle) / day 1 angle.
Percent change of Day 4 to Day 1=
100 x (day 4 angle – day 1 angle) / day 1 angle.

Results

Table (1) reveals that the 50 children in the study group were 29 males and 21 females with a mean age of 9.8±4.1 and range from 5.0 to 18.0 years. The majority of participants had thermal burns caused by hot water (58%), 24% of them exposed to open fire, followed by hot oil (18%), compared to 50%, 35% and 15% in the control group, respectively. Children in the study group having second degree of burn-depth represented 58%, whereas 42% of them were graded as a second to less than third degree of burn. The highest percentages of children (58 & 65%) in the study and control groups respectively, had burn of hands (fingers & wrist).

Table (2) shows an increase in percent change in ROM angle from Day 1 to Day 2 after application of the mobilization exercises, the mean percent change in angle by using Mann Whitney test for comparing the study and control groups revealed statistically significant improvements in wrist flexion, wrist extension and wrist radial deviation. Moreover, there are increases in ROM of MCP-finger's flexion, abduction and adduction movements. On the other hand, the joints of wrist ulnar deviation, MCP-finger extension and elbow flexion show slight improvements in ROM but do not reach statistically significant differences.

Concerning the percent change in ROM angle from Day 1 to Day 3 after exercises intervention, table (3) shows statistically significant differences in all ROM of the involved joints between the study group and the control group.

At the completion of the four sessions of intervention, table (4) demonstrates that the study subjects had gained the best percent improvements in the mean angle degrees of the elbow flexion (54.2±15.3) and wrist ulnar deviation (52.8±10.4). In contrast, results did not show any progress in ROM angles among burnt children of the control group even at the third or fourth days, especially in the wrist flexion that reached minimum change (4.6±4.5), and MCP-finger flexion (7.8±6.3) at the fourth day.

Findings in figure (1) indicate a significant improvement in supination and pronation angles of forearm better in the study than control group throughout follow-up for four days of the study intervention.

Figure (2) also illustrates ascending percent values in ROM of shoulder flexion and shoulder extension among children of the study group while the control group did not reveal a significant difference from the first until the fourth days.

Table 1: Personal and burn characteristics of patients in the study and control groups.

Children Characteristics	Study Group (n=50) No.	%	Control Group (n=40) No.	%	χ2 test	*p*-value
Age (years):						
<10	32	64.0	24	60.0		
10+	18	36.0	16	40.0	0.15	0.70
Range	**5.0-18.0**		**5.0-18.0**			
Mean±SD	**9.8±4.1**		**10.0±4.3**			
Gender:						
Male	29	58.0	27	67.5		
Female	21	42.0	13	32.5	0.85	0.36
Formal education:						
No	9	18.0	10	25.0		
Yes	41	82.0	30	75.0	0.65	0.42
Duration of burn (days):						
> 3	11	22.0	12	30.0		
7-	19	38.0	15	37.5	0.90	0.64
14+	20	40.0	13	32.5		
Burn location:						
Fingers and wrist	29	58.0	26	65		
Fingers, wrist and forearm	17	34.0	11	27.5		
Fingers, wrist, forearm, elbow and shoulder	4	8.0	3	7.5	--	--
Cause:						
Hot water	29	58.0	20	50.0		
Hot oil	9	18.0	6	15.0	0.64	0.73
Open fire	12	24.0	14	35.0		
Depth (degree):						
2	29	58.0	27	67.5		
2-<3	21	42.0	13	32.5	0.85	0.36
Type of ROM:						
Passive	17	34.0				
Active	33	66.0	--	--	--	--

(*) Statistically significant at p<0.05 *(--) Test result not valid*
ROM: Range of Motion

Table 2: Percent changes in angles of movements between the second and the first days among patients in the study and control groups.

Joint Movements	Percent Change in Angle (Mean±SD)# Study Group	Control Group	Mann Whitney test	*p*-value
Wrist flexion (palmar)	7.1±3.0	3.6±4.5	12.91	<0.001*
Wrist extension (dorsiflexion)	11.3±4.3	6.7±6.6	9.65	0.002*
Wrist radial deviation	12.8±4.3	4.6±12.2	7.30	0.007*
Wrist ulnar deviation	15.0±4.3	12.0±7.3	0.56	0.45
MCP-finger flexion	14.0±4.1	4.5±5.7	30.55	<0.001*
MCP-finger extension	8.4±3.3	5.6±2.9	0.22	0.64
MCP-finger abduction	14.0±4.1	1.3±7.7	31.15	<0.001*
MCP-finger adduction	13.9±4.1	7.8±8.1	8.73	0.003*
Elbow flexion	14.7±11.2	8.8±10.5	3.56	0.06

(#) Percent change = 100 x (day 2 angle – day 1 angle) / day 1 angle.
(*) Statistically significant at p<0.05
MCP: MetaCarpo-Phalygeal

Table 3: Percent changes in angles of movements between the third and the first days among patients in the study and control groups.

Joint Movements	Percent Change in Angle (Mean±SD)#		Mann Whitney test	*p*-value
	Study Group	Study Group		
Wrist flexion (palmar)	21.7±4.0	3.2±4.2	25.39	<0.001*
Wrist extension (dorsiflexion)	27.1±7.0	7.7±6.3	25.58	<0.001*
Wrist radial deviation	27.2±5.6	8.1±15.3	20.10	<0.001*
Wrist ulnar deviation	33.5±6.0	13.6±5.1	23.63	<0.001*
MCP-finger flexion	30.3±7.7	6.9±6.5	23.27	<0.001*
MCP-finger extension	31.7±5.2	15.8±7.5	6.43	0.005*
MCP-finger abduction	30.3±7.7	7.6±9.4	34.77	<0.001*
MCP-finger adduction	30.3±7.7	19.4±3.6	7.91	0.005*
Elbow flexion	35.5±15.5	8.0±6.4	9.74	0.002*

(#)Percent change = 100 x (day 3 angle – day 1 angle) / day 1 angle.
(*) Statistically significant at p<0.05

Table 4: Percent changes in angles of movements between the fourth and the first days among patients in the study and control groups.

Joint Movements	Percent Change in Angle (Mean±SD)#		Mann Whitney Test	*p*-value
	Study Group	Study Group		
Wrist flexion (palmar)	40.9±6.5	4.6±4.5	51.56	<0.001*
Wrist extension (dorsiflexion)	41.5±7.3	9.9±6.6	49.38	<0.001*
Wrist radial deviation	42.2±6.8	10.2±8.6	49.49	<0.001*
Wrist ulnar deviation	52.8±10.4	16.6±3.6	51.95	<0.001*
MCP-finger flexion	50.7±7.5	7.8±6.3	47.22	<0.001*
MCP-finger extension	46.8±8.3	17.6±1.2	47.44	<0.001*
MCP-finger abduction	50.7±7.5	11.8±7.9	46.65	<0.001*
MCP-finger adduction	50.7±7.5	20.3±7.1	45.94	<0.001*
Elbow flexion	54.2±15.3	15.4±10.8	16.23	<0.001*

(#)Percent change = 100 x (day 4 angle – day 1 angle) / day 1 angle.
(*) Statistically significant at p<0.05

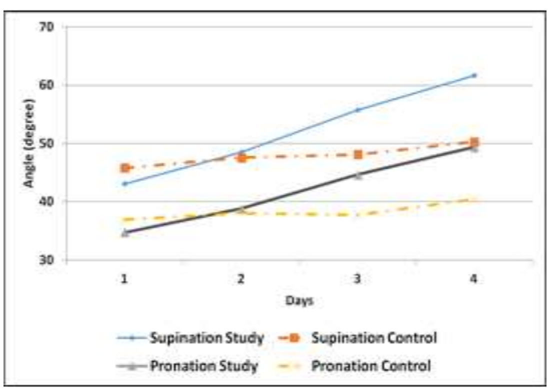

Figure 1: Comparison of supination and pronation angles of forearm between study and control groups throughout follow-up days.

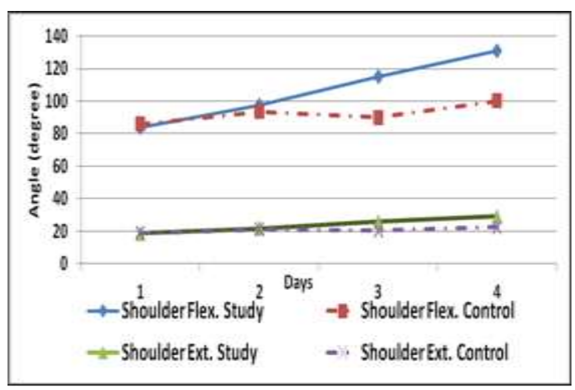

Figure 2: Comparison of shoulder flexion and extension angles between study and control groups throughout follow-up days.

Discussion

Post burn contractures are distressingly common and severe in developing nations and are a significant problem in developed countries as well (Schwarz, 2007). Attention now is being directed to optimizing functional outcome for these children post-burn injury (Klein *et al.,* 2007). Moreover, post-burn scars are inevitable even with the best of treatment because they depend upon the depth of burn injury. Except for the superficial dermal burns, all deeper burns heal by scarring (Goel & Shrivastava, 2010).

Data were first collected about characteristics of children burn survivors for application of the inclusion criteria. Children with second-degree burnt shoulder were selected and sessions of mobilization exercises started. The study findings indicated low range of motion scores among children in the control group who were not exposed to the purposive mobilization exercises. This technique particularly is of major importance since time is critical for the decision to start applying the mobilizing intervention.

As predicted, the highest percentages of children had thermal burn of hands that includes fingers and wrist. The hand is vital to human function and appearance. It is also the most frequent component of burn injuries, as it is commonly used in reflex action to protect the face and extinguish the fire. The hand burn alone is not a life threatening but may seriously impair the patient's ability to function (Omar *et al.,* 2004). Moreover, the hand is a unique tool of accomplishment, not only in our everyday domestic work and leisure activities. Just as importantly, it is an organ of expression that is used to convey emphasis and to communicate language. The hand has 19 intrinsic muscles and about the same number of tendons whose origin is in the forearm (Boscheinen-Morrinm & Conolly, 2001). Thus, the hand has multiple functions associated with activities of daily living. The primary functions are to grasp, manipulate objects, and receive sensory information (Clarkson, 2005). In the current study, burns of wrist and fingers constitute most hand burns in both study and control groups; consequently, the magnitude of the problem is directed to the most common and clinically significant complication of burn injuries such as contractures, leading to decreased range of joint motion and joint deformities (Esselman, 2007).

In the event that thermal injury of the hand is characterized by disfigurement and deformity with marked problems because the patient is no longer able to perform the daily living activities and functions at school or work (Omar & Hassan, 2010). So that, scar management is an important aspect in the rehabilitation of burn survivors because scar tissue causes deformity and loss of ROM function (Edgar & Brereton, 2004). Therefore, some burn contractures can be sufficiently treated by mobilization exercise or serial casting (Schwarz, 2007).

Proportionately, sociodemographic data of the children were compatible with a study of El-Badawy and Mabrouk (1998), who indicated that more boys than girls of burned children between 8–15 years from lower socioeconomic class; 56.7% of them formed scalds as the cause of burns, while 38.6% were due to flame, presented to the burn unit of Ain Shams University. Al- Shehri (2004); Ball *et al.* (2010); and Kim *et al.* (2011) reported scalds as the cause of the majority of burns to young children. In congruent with the present results, Hemeda *et al.* (2003) reported that most children were mostly burned due to accidents at home and were mainly victims of scald and flame burns.

Range of Motion Assessment Chart was used for appraisal of ROM throughout four days of the study intervention. Range of motion refers to the distance and direction a joint can move to its full potential. A goniometer is an instrument that was used to measure ROM of each specific joint in degrees when fixed on the axis of the joint (Ball, 2010). Furthermore, the size of the goniometer should be appropriate to the joint being measured. The arm of the goniometer used to measure the wrist and forearm is about 15 cm in length compared to the 4-6 cm arm needed to assess digital range of motion. While measuring finger joint ROM, the wrist should be held in neutral and the forearm in pronation (Boscheinen-Morrinm & Conolly, 2001).

The goal of the mobilization exercises in this study is to increase gently ROM of the affected shoulder among children with second degree of burn. There are two main types of the study intervention, firstly, the active ROM that the patient exercises without any assistance; and passive ROM when a nurse or a therapist moves patient through ROM without any effort from patient (Ball, 2010). Accordingly, passive mobilization exercises of any joint were done during times when patients cannot perform active mobilization exercises. In this regards, Spires, *et al.* (2007) emphasized that grafts, synthetic dressings, escharotomies and surgical debridements are not contraindications to exercise, depending on type of graft, condition of the graft wound, and judgment of the surgeon. In the current study, mobilization exercises were commenced prior to skin healing after three days or more when appropriate.

Firstly, the child was instructed to rest the forearm firmly on a tabletop and hang the hand over the edge of the table. Next, the researchers asked the child to bend the wrist up and down as far as possible, this tests wrist flexion and extension. Finally, further tests of wrist radial and ulnar deviations were done by asking the child to put the forearm with his/her palm down, on the table, and move the hand toward the little finger side, then, move the hand toward the thumb side with keeping the forearm still on the table (Iyer, 2011).

The role of nurses is teaching the parents and child about mobilization exercises during hospitalization, until joints' function has peaked, and to prevent flexion contractures, which severely limit mobility and may require surgical correction. This point was taken into account in the present study and certainly contributed to the positive impact of the applied exercises. Accordingly, mobilizing the affected limb started by helping the participating child to be in a comfortable position, then moving the affected joint to a considerable maximum mobility to obtain best overall improvement in ROM. In addition, the nurse also uses good body mechanics during the exercises session (Smeltzer *et al.,* 2010).

Furthermore, Bowden and Greenberg (2010) identified that, if the child was able and willing to cooperate, active ROM exercises of the burned areas had been used to promote optimal functional recovery. In congruence, Moore *et al.* (2009) suggested that a program of active exercises is appropriate when the patient is alert and able to participate, to reduce contractures and functional loss, and getting an increase in ROM angle. Therefore, Spires *et al.* (2007) highlighted that, moving the burnt joint is to be slowly and repeatedly to its permitted range several times, and maintained according to a sustained force of the child.

Nevertheless, children who were unable to move or unwilling to cooperate, the researchers applied passive mobilization exercises to help them maintain function of burnt limb, improve ROM and prevent stiffness developing, as mentioned by Procter (2010) that, despite intervention was not possible on a daily basis, it had been achieved during change of dressings. At that time, intervention and ROM assessment were appropriate for the study group of children. Cautiously, the affected joint was flexed and extended, abducted and adducted, or rotated to avoid causing extra pain. Limitation in movement may indicate injury, inflammation, or malformation. Ball *et al.* (2010) clarified that ligaments of the arms are normally straight, with a minimal angle at the elbows, where the bones articulate. Therefore, children in the study group moved each involved joint to the point of resistance and stopped at the point of pain. Hence, gentle steady pressure is applied until the child relaxed, and motion is continued to the joint's final point of resistance (Smeltzer *et al.,* 2010).

During the implementation stage of the study, each participant child was asked to make a fist, being sure each joint is bending as much as possible. This to test MCP flexion/extension. Next, the researchers asked the child to rest the hand on the table with the palm down, and spread fingers wide apart and bring them together again to test MCP abduction and adduction. In a study of (Iyer, 2011) to test the elbow flexion and extension by asking the patient to place arms down at side with elbows straight, and bend the elbow and bring the hand up to touch the shoulder. Due to the fact that, the elbow has an important main function for children, which is to bring the hand to the mouth and head; this is why mobilization exercises are important to increase elbow ROM for burnt shoulder.

Finally, to examine shoulder flexion, subjects were instructed individually, to hold a stick or ruler with both hands hip width apart, elbows straight and palms facing body. Then, the participated child was asked to move the humerus straight anteriorly. The child could lift the affected arm with the unaffected arm straight up to raise both arms overhead until the child felt a comfortable position. McClure *et al.*, (2004) pointed that in order to test shoulder extension, the patient should move the humerus straight posteriorly with keeping the trunk upright.

Generally speaking, findings of this study revealed that differences in ROM angle between both the study and control groups did not reach to be statistically significant from Day 1 to Day 2 after exercises' intervention for the joints of wrist ulnar deviation, MCP-finger flexion, MCP-finger extension and elbow flexion. At the completion of four sessions of intervention, the study group had gained the best measurements of ROM angle degree in all exercised joints, especially the percent change of elbow flexion and wrist ulnar deviation, whereas few differences were detected in all ROM of joints among children of the control group. Ultimately, although scar assessment was not an objective, the researchers noticed that scars became softer and skin around is easily stretched and pink colored in a comparison to the red color and firm skin without exercises to the control group.

Conclusion

The study supported the hypothesis that providing purposeful mobilization exercises can optimize range of motion stage of shoulder as well as the elbow and wrist joints in the majority of children with second-degree burn.

Recommendations

Based on the study findings, it is recommended that well-trained nurses should apply mobilization exercises at burn units. Further studies are needed to establish the long-term outcome for the burnt children for evaluating the effect of mobilization exercises on ‘‘new’’ versus ‘‘old’’ burn scar.

More researches are needed to explore the benefits of repeated treatments of mobilization exercises on patients with a larger sample that could verify this positive trend.

Conflict of interest statement

No authors have any financial or personal relationships with other people or organization that could inappropriately influence their work.

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