EFFECT OF VIRTUAL REALITY EXERCISE ON PAIN AND RANGE OF MOTION IN PEDIATRICS WITH SECOND DEGREE ANTERIOR SHOULDER BURN INJURIES

Heba Alaa Eid [1], Amal Mohamed Abd El Baky [2], Mahmoud Abdel Fattah Farid [3] Hussein Gamal Hussein Mogahed [4]

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Abstract:

Background: After motor vehicle accidents as well as drowning, burns are the 3rd leading cause of injury-related mortality among children under the age of 14. Hospital stays for burn victims are the longest of any type of injury, and the costs connected with their care are among the most expensive.

Purpose: The purpose of this study is to evaluate the efficacy of virtual reality exercise in reducing pain and increasing range of motion in children with second-degree anterior shoulder burns.

Methods:

Subject: Sixty patients who have 2nd degree anterior shoulder burn injuries and suffering from pain as well as limitation of shoulder ROM. Patients would be randomized into one of two groups, either group A (the study population) or group B (the control population), with each group containing thirty individuals. Patients in both groups were recruited from hospitals of Cairo University. All patients received active assisted exercise plus usual medical treatments including antibiotics, usual traditional pain medications before each treatment session, and anti-inflammatory drugs. Patients in Group A were treated for 30 minutes, twice weekly, for 4 weeks using active assisted exercise as well as fully immersed Head-Mounted Display virtual reality (an Oculus Quest VR headset along with a hand controller). Active assisted range-of-motion (ROM) physiotherapy was provided to patients in group (B) twice weekly for a total of four weeks. Initial measurements were taken before to treatment initiation, then again on the fourteenth day of treatment, and finally on day 28.

Results: - There were insignificant differences in all outcomes between groups at pre-treatment ($p>0.05$), except flexion. There were significant differences among groups in all outcomes ($p\leq0.05$) except abduction ($p=0.087$).

Conclusion: - virtual reality exercise is beneficial in improving pain as well as shoulder ROM in pediatric patients suffering from 2nd degree anterior shoulder burn injuries.

Key words (Virtual reality, quality of life scale and mobile application Goniometer).

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1 Assisted lecturer of physical therapy for surgery ,Faculty of physical therapy**,** Alhayah University In Cairo,
2 Professor of physical therapy for surgery, Faculty of physical therapy, Cairo University.
3 Assistant professor of plastic and burn surgery, faculty of medicine , Al-Azhar University.
4 Assistant Professor of physical therapy for surgery, Faculty of physical therapy, Cairo University.
Corresponding author Heba A. Eid

1.Introduction:

After motor vehicle accidents as well as drowning, burns are the 3rd leading cause of injury-related mortality among children under the age of 14. Hospital stays for patients with burns are the longest and most expensive of any type of injury admissions. Cald burns from hot liquids are the most prevalent type of burn injury in children, especially among those aged 0-4 years. Burns can also be caused by electricity, chemicals, or intentional injury. Children's injury mechanisms typically include their natural curiosity and lack of awareness of potential threats in their surroundings **(1)**.

Patients who have suffered severe burns must have the opportunity to receive intensive rehabilitation services. Shortly after a patient is brought to the hospital, rehabilitation starts, and it can involve a variety of interventions, such as therapeutic exercise. The development of permanent impairments due to burn scar contractures can be prevented through the use of therapeutic exercise. Examples of physiotherapy activities include both active and passive stretching

as well as strengthening. Joint range of motion (ROM) and function are preserved, and ambulation, conditioning, as well as endurance are improved as a result of these therapies **(2)**.

It has been shown that the use of immersive virtual reality (VR) as an adjuvant, nonpharmacologic analgesic during postburn physiotherapy can significantly reduce pain levels in patients. The virtual reality technology makes the user feel as if they have "introduced the 3-dimensional computer-generated environment. Many believe that people's interest in the virtual world is proportional to the intensity of their presence there. Virtual reality (VR) has been shown to be an efficient method of psychological pain management since it is so engaging. Pain intensity, unpleasantness, as well as the period of time patients spend concentrating on their pain can all decrease when they focus less on the problem **(3)**.

2. Materials and Methods:

Patients were randomized evenly (n=30) between the study as well as control groups in the present study. **In Group A**: Patients were given 30 minutes of active assisted exercise as well as 4 weeks of virtual reality therapy using a fully immersed Head-Mounted Display (an Oculus Quest VR headset using a hand controller) twice weekly.

Group (B): Received active assisted ROM physiotherapy 2 times a week for 4 weeks.

Inclusive Criteria included:

1-All the patients age were ranged between 5-16 years.

2-Both sexes were participated in the study

3- Patients who suffered from anterior shoulder burns with involvement of axillary fold

4-patient who suffered from second degree burns

5- patients were acute cases.

Exclusive Criteria included:

1- Patients having face or head trauma.
2- Wounds in hands
3- Cognitive disorders
4- History of motion sickness
5- Mental health disorders.

Ethics

The physical therapy faculty at Cairo University, Egypt, gave their approval to this study's protocol (No:P.T.REC/012/003467). Before beginning the trial, all caregivers gave their informed consent. Everyone in the study was made aware of the treatment methods and their potential outcomes. Patients were also asked to report any negative reactions to treatment.

3. Measurements

a- -Mobile application Goniometer for ROM assessment:

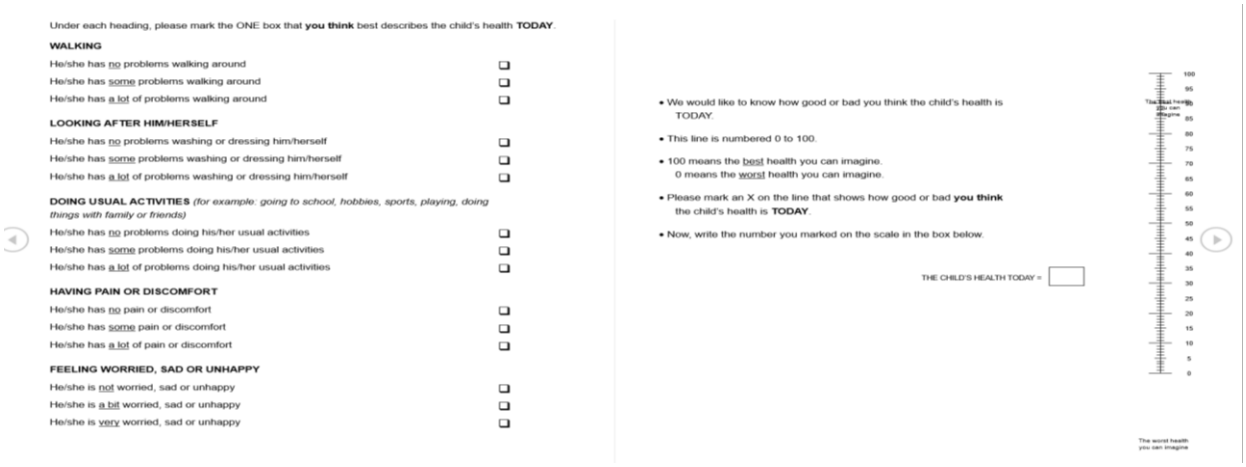
The study involved the use of a single iPhone (Model 13 promax) and the photo capture-based applications DrGoniometer (version 1.2; CDM S.r.l., Milano, Italy)(4), neither of which were updated throughout data collection. All subjects were measured with their shoulders exposed, and the results were as follows: active forward flexion motion (see Fig. 1), complete abduction was measured multiple times to rule out the possibility of error due to compensatory movements like trunk extension or scapular elevation. The range of motion (ROM) of the participant's shoulder was initially measured by attaching a smartphone goniometer (Dr. goniometer) to an armband around the distal humerus and having an observer take pictures of the shoulder in various positions.

The shoulder abduction position required full pronation of the forearm and medial rotation of the shoulder. Two centimeters above the wrist, a looped strap was attached. Participants were told to extend their elbows to their full range of motion while lifting. The experiment was done twice more, with the best result taken for the final score.

Figure 1. Measurements of forward flexion,

b- The Quality-of-Life Scale for Children to evaluate the psychometric properties:

The usage of Health-Related Quality of Life (HRQoL) measurements has increased as researchers have become more interested in the topic of QoL. There is widespread agreement that physical, mental, as well as social health are all crucial to optimal functioning, hence these are the areas that should form the basis of HRQoL assessments. (5) The goal of generic HRQoL assessments is to accurately represent an individual's true impression of their health. These measurements give information that can be utilized to assess the efficacy of treatments in clinical trials for a wide range of medical disorders, inform government and organization policies, and improve patient healthcare experience **(Figure 2).**


Under each heading, please mark the ONE box that **you think** best describes the child's health **TODAY**.

WALKING
He/she has no problems walking around
He/she has some problems walking around
He/she has a lot of problems walking around

LOOKING AFTER HIM/HERSELF
He/she has no problems washing or dressing him/herself
He/she has some problems washing or dressing him/herself
He/she has a lot of problems washing or dressing him/herself

DOING USUAL ACTIVITIES *(for example: going to school, hobbies, sports, playing, doing things with family or friends)*
He/she has no problems doing his/her usual activities
He/she has some problems doing his/her usual activities
He/she has a lot of problems doing his/her usual activities

HAVING PAIN OR DISCOMFORT
He/she has no pain or discomfort
He/she has some pain or discomfort
He/she has a lot of pain or discomfort

FEELING WORRIED, SAD OR UNHAPPY
He/she is not worried, sad or unhappy
He/she is a bit worried, sad or unhappy
He/she is very worried, sad or unhappy

- We would like to know how good or bad you think the child's health is TODAY.
- This line is numbered 0 to 100.
- 100 means the best health you can imagine. 0 means the worst health you can imagine.
- Please mark an X on the line that shows how good or bad **you think** the child's health is **TODAY**.
- Now, write the number you marked on the scale in the box below.

THE CHILD'S HEALTH TODAY =

Figure 2: Quality of life scale

c- Smart phone version of visual analogue scale (VAS) for measuring the pain :

The VAS-100 as well as NRS-11 smartphone versions have been compressed to fit on the 3.5-inch diagonally iPod Touch screen (Apple Inc., Cupertino, CA, USA) and were set against light blue backgrounds for increased readability. See Figure 3. The Panda VAS-100 scale is 6.7 centimeters in length. When a user taps the line, a "X" appears to indicate the precise location along the scale where they are experiencing the most pain. Based on how far away from both ends of the line the marker is, an integer score among 0 and 100 is assigned. The Panda NRS scale measures out at a length of 6.3 centimeters. A red "X" appears above the number that is nearest to where the user contacts the line. The subject's pain level is recorded, and the marker is placed over the corresponding number. The research participants' iPods were used to upload the data **(6).**

Figure 3: the Panda version of the visual analogue scale (VAS-100)

Treatment procedures

Group A (Experimental group). Were given active assisted exercise and VR headset with touch controllers

The therapeutic motions needed for ULI recovery were integrated into a variety of games. In The Climbing Game, the child had to work on their upper-body strength by lifting their arms above their heads. Bricks and cables were shown off in the center of attention. The child dropped their arm after grasping the brick and started climbing.

The Basketball game the child had to raise their hands up to through the ball inside the hanging basket.

Group B (Control group). were given only active assisted ROM physical therapy treatment.

Statistical procedures

Statistical package for social sciences (SPSS) version 24 was utilized for all analysis. **(7)**

4. Results

***Subject characteristics*:**

Baseline characteristics of all patients in both groups were presented in table (1) and figure (1). Groups were not different significantly in baseline characteristics (p>0.05), except total body surface area (TBSA) (p=0.004). However, TBSA was only weakly correlated with improvements in only some outcomes post-treatment.

Table (1): Baseline characteristics of patients in both groups

Baseline characteristics	Group A	Group B	*P*
Age, years, mean (SD)	11.1 (2.48)	9.8 (2.97)	0.085
Total body surface area, cm^2, mean (SD)	16.2 (8.4)	11 (3.48)	0.004*
Sex (count)			
Male	14	11	0.75
Female	15	14	

SD: standard deviation; (*): significant at p<0.05

Within-groups comparisons:

Means (SD) of shoulder mobility (flexion and abduction), pain, quality of life, and today health scores were presented in table (2) and figure (2). There were substantial improvements in all outcomes post-treatment in the two groups (p< 0.001). There were significant improvements in shoulder pain and mobility post-treatment at day 14 in the two groups (p< 0.001) and further significantly improved at day 28 (p< 0.001). As shown in table (2).

Table (2): ***Descriptive and analytical statistics of shoulder mobility (flexion and abduction), pain, quality of life, and today health within and between groups***

Outcomes	Group A Mean (SD)	Group B Mean (SD)	*p*
Shoulder flexion range of motion			
Pre	107.66 (29.5)	92.6 (11.4)	0.015*
Post14	141.34 (25)	132.9 (14.96)	<0.001*
Post28	174.7 (5)	169.5 (8.43)	<0.001*
Pre vs. Post 14, MD (p)	-33.7 (<0.001*)	-40.3 (<0.001*)	
Pre vs. Post 28, MD (p)	-67 (<0.001*)	-76.9 (<0.001*)	
Post 14 vs. Post 28, MD (p)	-33.3 (<0.001*)	-36.6 (<0.001*)	
Shoulder abduction range of motion			

Pre	73.2 (31.5)	68.5 (18.4)	0.49
Post14	112.6 (38.6)	112 (28.7)	0.95
Post28	161.6 (17.1)	168 (9)	0.087
Pre vs. Post 14, MD (*p*)	-39.3 (<0.001*)	-43.5 (<0.001*)	
Pre vs. Post 28, MD (*p*)	-88.3 (<0.001*)	-99.5 (<0.001*)	
Post 14 vs. Post 28, MD (*p*)	-49 (<0.001*)	-56 (<0.001*)	
Pain (visual analogue scale)			
Pre	8.38 (1.05)	8.5 (1.39)	0.67
Post14	5.28 (0.88)	6.48 (1.05)	<0.001*
Post28	1.66 (1.23)	2.36 (1.04)	0.028*
Pre vs. Post 14, MD (*p*)	3.1 (<0.001*)	2 (<0.001*)	
Pre vs. Post 28, MD (*p*)	6.7 (<0.001*)	6.16 (<0.001*)	
Post 14 vs. Post 28, MD (*p*)	3.6 (<0.001*)	4.12 (<0.001*)	
Quality of life (EQ-5D-Y)			
Pre	12 (1.4)	12.24 (1.2)	0.51
Post28	6.38 (1.05)	8.8 (1.5)	<0.001*
Pre vs. Post 28, MD (*p)*	5.6 (<0.001*)	3.44 (<0.001*)	
Your health today			
Pre	17.24 (9.9)	14.6 (6.9)	0.27
Post28	79.2 (9.8)	73.7 (10.6)	0.05*
Pre vs. Post 28, MD (*p*)	-62(<0.001*)	-59.1 (<0.001*)	

p: probability value; (*): significant at p<0.05; SD: Standard deviation; MD: Mean difference; Pre: pre-treatment; Post14: at 2 weeks of treatment; Post 28: at 4 weeks of treatment.

Between-groups comparisons:

There were insignificant differences in all outcomes between groups at pre-treatment (p>0.05), except flexion. There were substantial differences between groups in all outcomes (p≤0.05) except abduction (p=0.087) post-treatment at day 28, in favor of group A. There were substantial differences (p≤0.001) between groups in shoulder pain and mobility except abduction (p=0.95) post-treatment at day 14, in favor of group A. As shown in table (2).

5. Discussion

The research group (those who received VR) experienced significantly less discomfort and more range of motion following its application than the control group (those who did not get VR).

Even though it is painful, physiotherapy is an essential part of treating burn victims. The restricted range of motion as well as severe contractures that can result from a burn injury or the related skin grafting can be minimized with early and intensive physical treatment. Rehabilitation therapy after a burn injury is typically crucial in maximizing functional outcomes and reducing the likelihood of permanent disability. The severe procedural pain that might be induced by the very exercises meant to help patients heal can discourage their full participation in physical therapy **(8)**

Size as well as the price of equipment, lack of technical resources, hardware/software failures, and worries about infection control are only some of the obstacles to using VR in a clinical context. A virtual reality software may fail due to these restrictions. Time spent on VR equipment installation, breakdown, and cleansing should also be included in. Patients with a history of motion sickness or epileptic seizures may also be excluded from using burn mapping. The high cost and limited availability of hardware equipment makes it difficult to consider clinical applications of high-end VR technology. Full and broad installation in the clinical setting requires more readily available and less expensive high-tech equipment **(9)**

5.1- Children's ratings of difficulty, enjoyment and pain with VR:

The findings of the present study showed substantial differences (p≤0.001) between groups in shoulder pain.

Children that used HMD-VR for their recovery reported having a better time and experiencing less discomfort during the activities compared to their traditional rehabilitative experiences. Overall, reports of pain and difficulty were less severe than normal **(10)**

When compared to normal analgesics alone, supplementary virtual reality (VR) has been shown to reduce subjective pain scores by 30% to 50% during burn wound care and following burn healing physiotherapy. Using VR, Hoff man et al.1 showed that the reported pain score might be lowered. McSherry et al. found that virtual reality's pain-relieving effects might be maintained while using a less amount of opioids. There have been states of VR's analgesic efficacy even in cases of acute excruciating pain, contradicting earlier studies that distraction techniques fail to generate meaningful

analgesia above a specific higher pain threshold. These studies suggest that virtual reality-assisted analgesia may have additional effects beyond those of purely cognitive distraction **(11)**

Although distraction is still a key component, the analgesic impact of VR may be mediated in part by the modulation of brain areas that are not normally involved in the primary pain network. In a surprising study, participants who were subjected to severe arm stimulation reported feeling less pain when their virtual arm in VR seemed protected compared to when it did not **(12)**

The brain's sense of pain is a complex process that, despite significant study, is still not fully understood. The brain's cortex and subcortex both play a role in the various stages of pain signal processing. In along with noxious sensory input, many other factors, such as one's current emotional state, one's memories, one's state of mind, one's level of alertness, one's focus of attention, one's expectations, and so on, all play a role in shaping the subjective feeling of pain **(13)**

There is also a lack of agreement regarding the process by which virtual reality can alleviate subjective pain. It appears that virtual reality's main mechanism of action is distraction, with the goal of redirecting the patient's attention away from the painful experience. Isolation from the outside world and full immersion in a computer-generated, multisensory, and potentially interactive simulation are both effective methods of distraction. Virtual reality (VR) distraction is more successful than traditional methods like listening to music, viewing videos, or playing video games because of VR's ability to incorporate many sensory and even motor inputs into the experience. Users have reported feeling less pain while using virtual reality systems if those systems are more immersive. It is believed that the patient's experience would improve as a result of efforts to lessen the sensory overload that comes with receiving acute painful therapy **(14)**

Maximum joint range of motion did not improve significantly in the VR condition when compared with the control condition ($p = 0.21$). However, range-of-motion results were affected by the order of treatments. irrespective of the order in which the individual treatment conditions were administered, the second treatment condition resulted in a statistically significant improvement in maximal range of movement (mean increase 6.8 degrees, $p = 0.03$) **(15)**

Throughout burn wound debridement, patients in a recent study experienced less intense pain, less unpleasant pain, and less time spent thinking about their suffering. These findings represent the first controlled study showing that virtual reality (VR) may decrease severe to excruciating pain throughout burn wound debridement. Furthermore, the presence of severe pain did not appear to diminish the effectiveness of virtual reality distraction, as the 6 patients with the most severe worst pain ratings remaining demonstrated a 41 percent reduction in pain during VR. Furthermore, this is the first study to demonstrate that a photonic, water-friendly VR delivery method may be beneficial alleviation technology for patients suffering from burn injuries who need wound care in the hydrotank, in which traditional electronic VR delivery systems cannot be feasible due to possible patient safety dangers **(16)**

mean subjective rating of pain decreased by 20-37% using immersive VR during passive ROM treatment, with the greatest sample size of 146 analgesic comparisons in 88 participants aged 6 to 65 years. In addition, there was no correlation between gender, race, the severity of the burn at the outset, or the length of time spent in VR for distraction purposes and the degree to which pain was alleviated. Users of different ages gave different ratings to the virtual environment's reality and their own sense of immersion in the virtual world, the authors found **(17)**

Children having an IV catheter inserted or a blood sample taken. Children suffer an extensive amount of distress and anxiety as a result of these surgeries. In a randomized controlled study (RCT), Chan et al. compared the effects of virtual reality (VR) distraction using an underwater environment vs standard of care (SOC) distraction using books and toys on pediatric patients. The Faces Pain Scale, a rating scale designed to quantify pain according to facial expressions, was utilized to record the primary outcome. Patients who required a venipuncture or IV placement and visited an outpatient clinic had their baseline pain assessed. While there was an increase in pain for all groups, the VR group's increase was smaller at 130% in comparison with the SOC group's 190% **(18)**

Patients were divided into two groups according to their pain levels during the No VR phase of the wound care session to determine if VR would be more useful for those with low to moderate pain or those with severe pain. To put it another way, the six patients with the greatest pain intensity ("worst pain") ratings throughout No VR reported a substantial 66% decrease in pain unpleasantness throughout VR, a 70% decrease in time wasted thinking about pain throughout VR, and a hundred percent rise in enjoyment during VR **(19)**

5.2- ROM readings:

The findings of the present study showed substantial differences ($p \leq 0.001$) between groups in shoulder mobility.

This finding has clinical relevance since it shows that VR can reduce pain complaints without significantly increasing range of motion. The ability to reduce pain and increase range of motion (ROM) are two separate factors that do not always go hand in hand. In this investigation, the therapist chose the range of motion (ROM) that was used. The extent to

which a therapist decided to exercise a joint may not have been affected by the fact that a patient reported reduced pain. Such conclusions may have been reached regardless of the patients' feelings by considering objective indicators like contracture rigidity or felt joint resistance **(20)**

Even though this study did not find a correlation between VR-assisted PT and increased clinical joint range of motion, measuring this outcome will be essential for future long-term studies of VR-assisted PT. Although not examined in the present study, it is likely that patients' perception of virtual reality treatment as less painful and more "fun" will lead to greater compliance and longer-term success. Outcome advantages for VR analgesia, such as improved range of motion after discharge, shorter hospital stays, and a decrease of chronic pain, may be revealed with prolonged treatments (of greater durations and frequencies). To evaluate whether patients who undergo systematic, recurrent usage of VR analgesia experience any long-term advantages, a large-scale, long-term, randomized controlled, between-subjects experiment is required **(21)**

5.3 The Quality-of-Life (QOL):

The findings of the present study showed substantial differences ($p \leq 0.001$) between groups in the quality of life in burned patients.

Quality of life after a burn is a changing, multi-factoral indicator. Since most patients make rapid recoveries following the early phase of injury and rehabilitation, determining when QoL is assessed is essential **(22)**

It makes sense that before one may return to role activities (home duties, leisure, working), one must first restore basic functional abilities (i.e., range of motion, strength, etc.), which are covered by the Qol. Therefore, the rise in Physical Domain scores between 2 and 6 months post-discharge likely reflects the return to previous job activities **(23)**

Limitations:

This study is not without limitations, the number of patients was too small to identify the improvement in pain as well as ROM in pediatrics with 2nd degree anterior shoulder burn injuries and the reason behind this was the small number of pediatric burned patients compatible with the criteria of selection of subjects in this study.

Conclusion

It proved that children with 2nd degree anterior shoulder burns benefited from VR treatment in terms of both pain as well as range of motion.

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