

Effect of Physical Rehabilitation Program Based on Range of Motion Exercise on Hand Joints Function among Patients with Thermal Burn

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Abstract:

Background: Hands are the most common burn injury sites. Appropriate range of motion exercise is essential to ensure good hand functional recovery. **Aim:** to evaluate effect of physical rehabilitation program based on range of motion exercise on hand joints function among patients with thermal burn **Research design:** A quasi - experimental (pre / post assessment) design. **Setting:** the study was conducted in Burn Department, Intermediate Care Room and Burn Outpatient Clinic at the Main Assuit University Hospital. **Sample:** A purposeful sample of (30) patients, their ages ranged from (20 - 65) years. **Tools:** **tool (1):** Patients structured interview questionnaire. **Tool (2):** Hand Burn Severity assessment scale. **Tool (3):** Hand contracture severity rating scale. **Results:** More than half of the patients were males and married (56.7% & 53.3%), (80%) of them had flame thermal burn & (50%) represented by 2nd degree burn with zone A (TBSA). There was a statistical significance difference as regard patients range of motion of mean score of different hand joints mostly in flexion between pre & post (3&6 weeks after program implementation ($p < 0.005$). **Conclusion:** significant improvement in hand joints range of motion function among patients with thermal burn post physical rehabilitation program application. **Recommendation:** using new physical rehabilitation modalities as Smart Glove that can be operated only through active ROM movement for patients with burn hand

Keywords: Hand Joint Function, Physical Rehabilitation Program, Range of Motion Exercise & Thermal Burn

Introduction:

Thermal burn injuries are the most common form of burn trauma that everyone may experience them. The hands are affected in (80%) of burn injuries due to their anatomical position in the body. It is an injury to the skin or other organic tissues caused by hot liquids & solids, and flames (Deng, et al., 2017).

Multiple physical complications following hand burn injuries emphasize the need for proper management, it has been indicated repeatedly that the use of evidence-based guidelines by healthcare providers is a useful way of achieving optimal functional outcomes with fewer disabilities in hand burn patients (Bayuo, et al., 2016). Also hand burn can make it difficult to do activities of daily living like dressing, eating, and grooming, as well as fine motor functions like typing, writing, occupational activities, joint abnormalities, sensory impairment, scar contracture, and post burn edema are all common problems after a hand burn (So- Young et al., 2020).

Furthermore hand burns have catastrophic implications not just in terms of functionality but also

in terms of aesthetic appearance. Because of the hand's particular anatomical structure, deep burns can cause serious scar contracture abnormalities. Patients' quality of life is frequently harmed as a result of these malformations. As a result, good hand-burn recovery therapy is critical (Li et al., 2017).

Rehabilitation of the burned hand should be initiated early in the acute stages by means of individualized positioning, splinting, and exercise for improving functional activity. Frequent exercise throughout the day is more beneficial than one session of intensive exercise. Hand range of motion ROM was performed beginning with the proximal joints and continuing to the distally afflicted joints starting from wrist joint, Metacarpophala (MCP) joints, Proximal interphalangeal (PIP) joint, and distal interphalangeal (DIP) joint and ended by the Metacarpophalangeal joint of the thumb. There are three types of range of motion exercises; passive ROM, active assisted ROM & active ROM. The patients' mobility only limited by their pain tolerance. There were ten repetitions in each workout (William et al., 2020)

Physical rehabilitation of burns patients is a continuum of active therapy starting from admission. Throughout all phases of burn hand care; ROM is an important component for burn patients. As a result of bed rest, decreased protein, altered fluid and electrolyte levels, and inadequate circulation, joint function may deteriorate until contracture occurs. Early in the acute phase in wound burn treatment; all joints receive full ROM exercise which is repeated on a daily basis. Depending on the patient's needs, pain tolerance & skills; active and passive exercises may be combined (Yong et al., 2020).

In fact, the physiotherapy nurse has a vital role in providing and convincing the burn victim of the importance of ROM exercises in decreasing edema and conditioning the tissue increase movement & joint function, improving movement efficiency, increasing independence, decreasing pain, improving and maintaining joint integrity (Serghiou et al., 2016 & Sorkin et al., 2017)

Significance of the study:

From researcher's experience, it had been observed that burned patients could expose to joint contractors as a result of thermal injury which impaired the joint ROM. In addition to dysfunction of hand joints and negative consequences from it, so the physical rehabilitation program plays a vital role for improving function of hand joints and decreasing complications. This study would highlight the necessity of the patient involvement in physical rehabilitation program based on ROM to reduce hand impairments that affect the patient's independence and productivity post thermal burn.

Operational definitions:

Rehabilitation program: "a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment" this was supported by WHO (2021).

Physical rehabilitation: In this study, this variable refers to use of ROM exercises to aid in recovery and restore burn patients joint function by improving joint movement abilities, strength & daily living activities, this was supported by WHO (2021).

Range of motion exercise: refers to activity aimed to improving movement of specific joint especially fine motor skills as fingers flexion & extension, it measures the distance and direction that a hand joint can stretch. This was supported by (Behm et al., 2016)

Aims of the study were to:

General aim, Evaluate effect of physical rehabilitation program based on range of motion exercise therapy on hand Joints function among patients with thermal burn through.

Specific objectives:

1. Assess the level of hand joints function among patients with thermal burn.
2. Design and implement the physical rehabilitation program based on range of motion exercise therapy among patients with thermal burn.
3. Evaluate the effect of the physical rehabilitation program based on range of motion exercise therapy on hand joints function among patients with thermal burn.

Research Hypothesis:

In line with these aims, the following research hypothesis was formulated:

Null hypothesis: Hand joints function would be improved after receiving the physical rehabilitation program.

Alternative Hypothesis: Hand joints function would be improved among patients with thermal burn who received the physical rehabilitation program based on range of motion exercise.

Patients and Method:

Research design:

Quiz experimental (pre, post & follow-up) research design that utilized to conduct this study. Pre-test and post-test research is one of many forms of quasi-experimental designs utilized in a variety of sectors, including medical, nursing, and education. Pre-test and post-test evaluation enabled for rapid refining of instructor teaching or simulation technique and allowed for immediate assessment of an intervention (such as an education session). In addition to being a quick and convenient research approach, it also utilized to evaluate a target population to whom an intervention had been administered (Stratton, 2019).

Study variables:

The physical rehabilitation program based on range of motion exercise considered the independent variable in this study, while the dependent variable was: hand joints function.

Technical design:

Setting:

The study was conducted in Burn Department, Intermediate Care Room and Burn Outpatient Clinic at the Main Assuit University Hospital in the ground floor, the Burn Department consisted of the reception room and its contents, intermediate care room, four inpatient rooms, (males, females) and hydrotherapy dressing room & its contents. The flow rate of thermal hand burn patients was about 10 cases monthly. This is due to the increase in the number of patients attending the burn department annually, mainly from upper limb joint burn, more than other types, hoping to reach the provision of the best

physical rehabilitation exercises that helps patients to coexist and adapt optimal proper hand joint function.

Sample:

Purposive sample of thirty adult patients (males and females) admitted to Burn Department, age ranged from 20 to 65 years. A power calculation estimated that in order to detect an effect size of one group (pre / post test) with a p-value < 0.05 and 80% power, confidence level 0.95, so a sample size of (30) patients was needed. The study excluded patients who had first & fourth-degree burns (involving muscles, tendons, and bone injuries), musculoskeletal diseases (fracture, amputation, rheumatoid arthritis) involving the burned hand, neurological diseases (such as peripheral nerve disorders), preexisting physical and psychological disability (mental impairment that could influence the intervention), or severe degree of pain interfering with hand ROM exercises .

Tools: Three tools were used to collect data, were as follows;

Tool I: Patient structure interview questionnaire: This tool consisted of two parts

Part (A): Demographic data assessment for thermal burn patients:

It was developed to assess demographic characteristics, it consisted of (6 items) about age, gender, marital status, level of education, occupation nature & length of hospital stay.

Part (B): Patients medical data assessment: to assess the presence of concomitant medical problems (defined as medical problems that might alter the course of recovery from the burn, such as diabetes, hypertension, and renal disease.

Too II: Hand Burn Severity (HABS) assessment scale: The HABS score is a simple tool for stratifying severity of hand burns at the time of initial patient assessment. It was developed by **Bache et al., (2017)** to assess degree of burn to the following; Zone (Zone A, Zone B, and Zone C). Scoring was devised whereby the hand is divided into three anatomical areas, shown in (Fig. 1). Zone A is distal to the Metacarpo-Phalangeal (MCP) joints; Zone B is over the MCP joints. Zone C is proximal to the MCP joints, up to the proximal wrist crease.

Circle appropriate score. 0 = no burn; 1 = superficial partial thickness (first degree) burn; 2 = deep partial thickness (second degree) burn; 3 = full thickness (third degree) bur

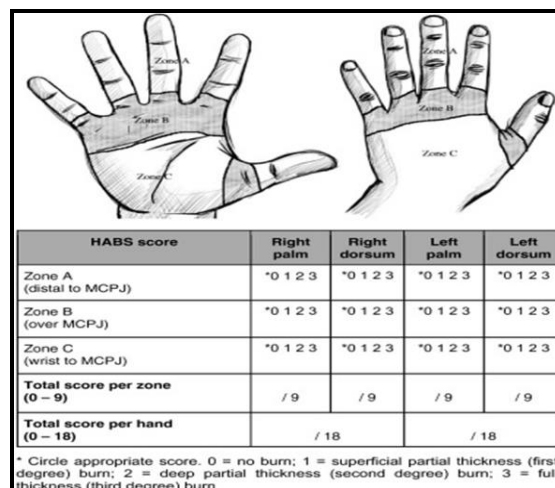


Fig. (1): Hand Burn Severity adopted from Bache et al., (2017)

- The three hand locations were thought to be wide anatomical zones that would have unique difficulties following a burn and could be easily identifiable by all users of the score. HABS score stratified hand burns according to severity with a numerical value of between 0 (no burn) and 18 (most severe) per hand.
- According to the depth of the burn, the volar and dorsal aspects of each hand were given a score for each of the three anatomical areas: 0 indicate no burn; 1 indicated a superficial partial thickness (first degree) burn; 2 indicated a deep partial thickness (second degree) burn; and 3 indicated a full thickness (third degree) burn. As seen in the diagram (Fig.1), this produces a possible total score of 18 per hand (**Bache et al., 2017**). The tool was demonstrating excellent inter-rater reliability ($r = 0.91, p < 0.0001$ on testing with Lin's correlation coefficient). Also a significant relationship was shown between the HABS score and a reliable outcome of the hand burn percentage and estimations the need for skin grafting on Mann–Whitney U testing ($U = 152; Z = 9.8; p = 0.0001$).
- **Tool (III): Hand severity rating contracture scale:** To evaluate hand joint function (pre and post), contracture which was created by **Jeffrey et al., (2006)**. It divided contracture into three categories (mild, moderate and severe contracture) **Table (1)**.The researchers used a goniometer and a defined technique to apply this tool fig.2 (A, B). (**Norkin, & White 2009**). This component was evaluated (pre, post 3 weeks & follow up post 6 weeks) after the patients were admitted to the burn department.

Joint	Action	Average Angle	Mild	Moderate	Severe
Wrist	Flexion	73°	40 to 59°	20° to 39°	Less 20°
	Extension	71°	40° to 59°	20° to 39°	Less 20°
	Radial deviation	19°	13 to 19°	6° to 12°	Less 6°
	Ulnar deviation	33°	20to 29°	10° to 19°	Less 10°
Metacarpo-phalangeal Digit	Flexion	59.1°	60 to 89°	30° to 59°	0 to 29°
	Extension	(-32°-58°)	-1° to -30°	-31° to -60°	-61° to -90°
Proximal inter-phalangeal digits 2-5	Flexion	100° to 110°	67° to 99°	34° to 66°	0 to 33°
	Extension	2°-5°	-1° to -33°	-34° to -66°	- 67° to -100
Distal inter phalangeal (DIP)Digit2-5	Flexion	45° - 50°	47° to 69°	24° to 46°	0°-23°
	Extension	10° to 25°	-1° to -23°	-24° to - 46°	- 47° to 90°
Thumb Interphalangeal	Flexion	90°	48° to 69°	24° to 47°	0° to 23°
	Extension	10°	-1 to -23°	-24° to -46°	-47° to -70°

The scoring of the tool: each joint, multiple planes of motion (flexion/extension) were measured. Each plane's joint muscle activity was assigned a normal (ROM). Each defective joint muscle movement was given a severity level; these ratings calculated by splitting the usual ROM value into thirds (mild, moderate, and severe (Table 1) & fig.2 (A, B). A contracture at a joint was defined as a limitation in the ROM in at least one plane of motion for the purposes of this study. In addition, if more than one muscle involved (Schneider et al., 2006).

Tool reliability:

Intrarater and interrater reliability were determined for hand finger range of motion (ROM) using finger goniometer. Reliability analysis was used to assess the consistency and stability of measures. Level of significance was set at ($p .05$) Significant differences ($p < .05$) existed between raters for metacarpophalangeal, proximal interphalangeal, and distal interphalangeal active finger ROM measurements and for metacarpophalangeal and proximal interphalangeal passive range of motion. Intrarater reliability ranged from (.43 to .99) (single measure intraclass coefficient). Interrater reliability ranged from (.24 to .95) with passive measures lower than active measures. These results provide clinicians with evidence for using this specific goniometer and issues associated with various therapists assessing hand finger ROM Lewis, et al., (2010).

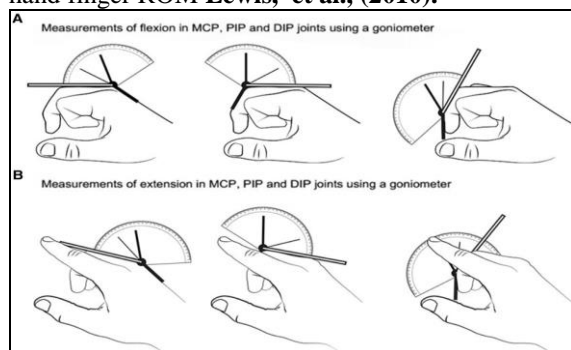


Figure (2): Burn finger goniometric measurements (A&B) adopted from (Norkin, & White 2009) & Hoyune et al., (2019)

Face validity: Content validity was done by six experts, (two professors from Medical-Surgical & two professors of Critical Nursing staff from Faculty of Nursing, Assiut University and two professors from Plastic Surgery and Burns staff ,Faculty of medicine, Assiut University hospitals , who reviewed the tools for clarity, relevance, comprehensiveness, understanding and applicability. Minor modifications were required and correction was carried out accordingly.

Pilot study: In December 2018, a pilot research was done on 10% of the sample to assess the feasibility and practicability of the study tools (3 patients). The purpose of the pilot study was to determine the tools' use, identify any concerns with the clarity of the statements that could block the data collection process, and estimate how long it would take to complete the interview schedule. Minor modifications were done to the tools, so the patients selected for the pilot study were included in the main study.

Method:

The program conducted in four phases (preparatory phase, planning phase, implementation phase and evaluation phase).

Phase I: The preparatory phase (Assessment phase):

- An official letter approval was obtained from the Dean of the Faculty of Nursing to carry out the study. Then Official approval & administration permission was obtained from the manager of the main Assiut University hospital to collect the necessary data.

- Tools development: The researchers designed and tested the study tools and the physical rehabilitation program after a review of current, past, local and international related literature in the various aspects using books, articles, periodicals and magazines were done David (2016) & (Hosseini et al., 2017), (Daffu et al., 2019), (Faris and Al Naser 2019) (Honnegowda et al., 2019), & (Kelly et al., 2019) (Nestor et al., 2020) then the final form of the proposed program was checked by a panel of experts to test content validity and reliability.

Phase II: Planning phase

- The physical rehabilitation program was designed based on analysis of the actual patients' needs in assessment phase. The program was written in simple Arabic language that was consistent with the related literature to meet patients' needs and their level of understanding.
- The program was presented to patients in the form of handouts and printed material. It included diagrams, pictures with colors which were primarily intended for attracting and guiding patients to actively participate in their management independently.
- Data collection lasted for 7 months through the period from December (2018) to June (2019).




Implementation phase:

Once authorization to proceed with the proposed study was given, the researcher began collecting data. The researcher collected the names of eligible patients who had been admitted to the unit and who fit the requirements from the patient's medical sheet.

Physical rehabilitation program based on ROM exercise

It was developed by the researchers based on literature review David (2016) & (Hosseini et al., 2017), (Daffu et al., 2019), (Faris and Al Naser 2019) (Honnegowda et al., 2019), (Kelly et al., 2019) & (Nestor et al., 2020) It was designed to maintain and improves joint function of the burned patients. This (ROM) exercises help to keep the muscles and joints flexible.

- The physical rehabilitation program regimen included the following; definition of ROM, benefits & types; as (wrist flexion/extension, wrist radial/ulnar deviation, and finger flexion/extension).
- MCP flexion by make a fist – heel of one hand may need to press on the back of the other hand near the knuckle joints.
- As regarding thumb abduction: put pads of index finger and thumb together and push apart, flexion; bend thumb to try to touch the bottom of the little finger
- The patients were given visual and audio feedback that indicated whether they had succeeded or failed. To achieve high scores, the patients had to accomplish a task accurately, on time, and with sufficient power

Wrist flexion	
Wrist extension	
Wrist extension with closed hand	
Wrist ulnar deviation	
Wrist radial deviation	

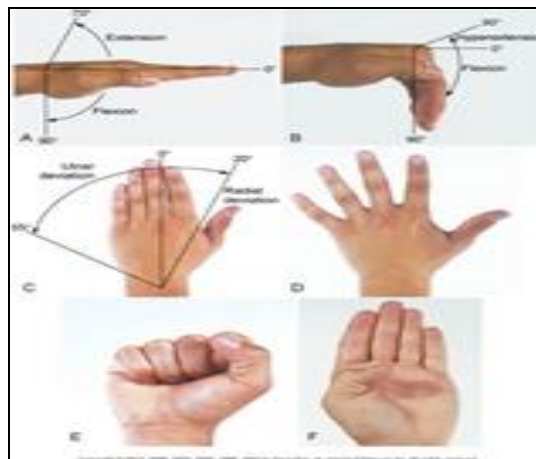


Fig (4): Range of motion exercise for hand joint adopted from David (2016) & Nestor et al.,(2020)

Plan of implementing the rehabilitation program:

To facilitate the implementation of the exercises rehabilitation program; researchers prepared program booklet, teaching aids and media (pictures, handouts). This was followed by arranging for the sessions schedule based on the contents as the following consequence

Formulation of program objectives: the purpose of the program was to improvement joints function after receiving the physical rehabilitation program based on range of motion exercise

Contents of the program:

- The rehabilitation exercises program contained four sessions. The duration of each session ranged from 30-45 min, according to the content of each session and patient needs. The researchers meet each patient individually and used some media as video and simulation in practice sessions to increase attention.
- Each session started by a summary about what discussed in the previous session.

Planning of action:

First session: Following fluid resuscitation for thermal burn patient, the first session began 24 hours after admission. Prior to any data collection, the researchers greeted the patients, and described the objectives of the study to those who decided to participate. After receiving the patient's oral consent for voluntary participation in the study, each patient was interviewed individually for the purpose of filling out the (Tool I & II) &, it took (10 - 15 minutes).

- One of family member was present in the session to encourage the patient and increase his or her sense of responsibility
- The researchers explained only the ROM regimen to the patient without patient demonstration in the first session as preparing to the second session it took (30 - 45 minutes) by using videos & photo illustrations

and colored pictures to be suitable for all patients needs and level of understanding.

- **Session contents:** the researchers verify the definition of ROM, benefits in hand joint function, types, and who applied.
- The researchers explained the steps of implementing ROM exercises by simulation the exercise step by step for all types of hand fingers joints.
- **Second session:** The researchers assessed hand joints function by using (Tool III) this part applied by using the goniometer.
- ROM exercises application started straight away (in the 3rd day) cross-joint hand burns .These joints were prone to contracture and should be treated with splinting and ROM exercises. Repeated each exercise for each hand joints 10 times three times a day until hospital patient discharge. it took (30 - 45 minutes).
- **Session contents:** demonstration and re demonstration for different hand joint exercises (wrist flexion/extension, wrist radial/ulnar deviation, and finger flexion/extension.
- There was roughly 10 - 15 minutes after the session ended for any explanation and comments. To ensure that the patient understood, reinforcement was done according to their needs.
- Each patient received a printed copy of the program booklet, and the researcher utilised graphics, videos to assist patients grasp and remember what they had learned.
- The researchers meet each patient individually in each session in the morning and afternoon shift.

Evaluation phase: (3rd & 4th session):

The researchers used (Tool III) (post 3 & 6) weeks from patient admission to measure hand joint function after demonstration of the program.

- Post-test was done after giving the ROM exercises program by 3weeks in 3rd sessions it took about 10-20 minutes for each patient before patient discharge from hospital.
- Follow up stage was done after 6 weeks later in out patient's clinic regarding it took about 10-20 minutes for each patient.
- **Sessions contents:** re- demonstrations for different hand joint ROM exercises.

Ethical Consideration:

Research proposal approved from the Ethical Committee in the Faculty of Nursing, Assuit University. There was no risk for study subjects during application of the research. The study was followed common ethical principles in clinical research. Oral consent was obtained from patients participated in the study, after explaining the nature and purpose of the study. Confidentiality and anonymity were assured. Study subject had the right to refuse to participate or withdraw from the study

without any rational at any time. Study subject privacy was considered during collection of data

Statistical analysis:

The researcher entered the study data using a suitable statistical programme for the social sciences (SPSS) version 22.0 software, and figures were created in Excel. The researcher analysed, categorised, and coded the material of each tool. Continuous variables were defined by mean and standard deviation, while categorical variables were expressed by number and percent (Mean, SD). Whereas the t-test , One way Anova& Peaarson correlation test used to analyse continuous variables significant difference at p. value<0.01

Results:**Table (I): Frequency & percentage distributions of studied patient as regarding to their demographic parameters (n= 30).**

Variables	Frequency	
	n.	%
A- Demographic Variables :		
Age group:		
20 - < 35	5	16.7
35 - < 45	15	50.0
45 – 65	10	33.3
Age range:		
Mean ± SD	41.3 ± 13.1(18-65) years	
Gender:		
Male	17	56.7
Female	13	43.3
Marital status:		
Single	12	40.0
Married	16	53.3
Widow	2	6.7
Educational level:		
Illiterate	9	30.0
Read and write	2	6.7
Preparatory school	4	13.3
Secondary school	13	43.3
University education	2	6.7
Occupation:		
Farmer	1	3.3
Student	5	16.7
Machinery work	13	43.3
Housewife	11	36.6
Length of hospital stay:		
Mean±SD(range)	25.8±15.4(3-72) days	
B- Presence of concomitant medical problems as:		
Diabetes mellitus.	2	6.7
Hypertension	3	10.0
Renal disease	0	0.0

Table (2): Frequency & percentage distribution of studied patients as regarding to their Hand Buren Severity (HABS) (n. =30).

Variables	Frequency	
	n.	%
Subtypes of thermal burn:		
Flame	24	80.0
Scald	6	20.0
Percent of burn (TBSA) according Zone		
Zone (A) Distal Metacarpo-Phalangeal (MCP)	15	50.0
Zone (B) Over Metacarpo-Phalangeal (MCP)	12	40.0
Zone (C) Proximal Metacarpo-Phalangeal (MCP)	3	10.0
Degrees of thermal burn		
Superficial second degree	11	36.6
Deep second degree	15	50.0
Third degree burn	4	13.4
Skin graft needed		
Yes	6	20.0
No	24	80.0
First aid at home		
Yes	1	3.3
No	29	96.7

Table (3): Distribution of hand joint ROM function mean score among the studied patient in the three phases of physical rehabilitation program (pre , post 3 weeks and follow up after 6 weeks) (n. = 30).

Hands joints ROM function affected							
Joint	n. 30	Average angel	Pre program (on admission)	Post (after 3 weeks)	Follow-up (after 6 weeks)	Anova test	P- value
Wrist joint							
Flexion		73°	58.79±2.9	56.65±3.23	59.15±2.25	6.08	0.019*
Extension		71°	52.13±2.15	50.27±19.68	51.71±2.09	0.198	0.945 N.S
Ulnar deviation		19°	30±0	29.75±0.57	30±0	25.7	0.013*
Radial deviation		33°	20±0	19.96±0.2	20±0	1.2	0.373 N.S
Metacarpo-Phalangeal (MCP) joint							
Flexion		59.1°	87.5±4.09	85.73±5.09	89.46±1.9	6.77	0.002**
Extension		-32°-58°	-0.36±1.89	-1.02±2.22	-0.43±1.91	0.912	0.407 N.S
Interphalangeal joint (proximal) joint							
Flexion		100° -110°	97.89±2.69	96.03±5	98.79±1.2	5.07	0.009**
Extension		2-5°	-0.21±1.13	-0.79±1.42	-0.25±1.14	1.98	0.160 N.S
Interphalangeal joint (distal) joint							
Flexion		45° - 50°	67.25±11.26	63.39±9.06	69.39±0.99	3.97	0.029*
Extension		10° -25°	0±0	-0.46±0.92	-0.04±0.19	6.62	0.003**
Carpometacarpal Joint							
Flexion		90°	69.3±0.99	67.91±2.48	68.87±1.81	4.12	0.023*
Extension		10°	-0.22±0.8	-0.37±0.88	-0.26±0.81	0.262	0.794 N.S

- One way Anova,

Ns = Non significant difference P value > 0.05

* Significant difference at p. value<0.05,

** Significant difference at p. value<0.01

Table (4): Correlation Co- efficient between hand joint ROM function and (age, total body service area & hospital stay) in the three phases of physical rehabilitation program (pre, post 3 weeks and follow up after 6 weeks) (n. = 30).

Hands Joints ROM function n.(30)	Pre program (on admission)			Post (after 3 weeks)			Follow-up (after 6 weeks)		
	Age	TBSA	Hospital stay	Age	TBSA	Hospital stay	Age	TBSA	Hospital stay
Wrist									
Flexion	0.092	0.004	0.291	0.020	-0.130	0.157	-0.143	0.449*	-0.326
Extension	0.282	0.138	0.166	0.275	0.035	0.073	0.268	-0.078	0.130
Metacarpo phalageal (MCP) joint									
Flexion	-0.005	-0.224	0.049	0.065	-0.431*	-0.151	-0.071	0.001	0.095
Extension	-0.049	0.039	0.099	0.083	-0.283	-0.202	-0.066	-0.076	0.029
Interphalangeal joint (proximal)									
Flexion	-0.339	-0.185	-0.156	-0.032	0.021	0.240	-0.498**	-0.140	-0.048
Extension	-0.049	0.039	0.099	0.085	-0.302	-0.241	-0.064	-0.057	0.041
Interphalangeal joint (distal)									
Flexion	-0.103	-0.576*	-0.342	-0.057	-0.635**	-0.433**	-0.127	0.006	0.082
Extension	-	-	-	-0.197	-0.574**	-0.489**	-0.092	-0.579**	-0.349
Carpometacarpal Joint									
Flexion	-0.127	-0.058	-0.072	0.156	-0.734**	-0.525**	-0.031	-0.709**	-0.485*
Extension	-0.262	-0.008	-0.036	-0.091	-0.287	-0.272	-0.211	-0.128	-0.090

Peaarson correlation negative correlation,

* Significant difference at p. value<0.05,

** Significant difference at p. value<0.01

Table (1): Illustrates that, more than half of the studied patient were males and married (56.7% & 53.3%) respectively, with a mean age (31.3±13.1). More than one third of the studied patient (43.3 %) respectively were secondary education and had machinery works. Regarding to length of hospital stay the present study reveals that the mean hospital stay of studied patients was (25.80±15.42) days. Furthermore; the lowest percentages of the studied patients had diabetes mellitus and hypertension (6.7% & 10%) respectively.

Table (2): Clears that the highest percentage of the studied patient had flame thermal burn (80%). As regards to percent of burn (TBSA) according to Zone; (50%) of the studied patients were represented by Zone (A) Distal (MCP) joint, followed by Zone (B) over (MCP) joint (40.0 %), but the minority Zone (C) proximal (MCP) joint (10.0%). Concerning degrees of thermal burn; the study reveals that half of the studied patient (50%) had deep second degree of burn. In relation to skin graft needed, the study shows that the highest percentages (80.0%) did not need to perform grafting procedure. in addition (96.7%) of the studied patient did not do first aid immediately after exposure to thermal burn at home.

Table (3): Summarizes that hand affected joints function for patient with thermal burn was moderate limited & moderate contracture compared to the normal anatomical average angle before burn injury; In relation to wrist joint ROM mean score of the affected hand in (flexion & extension motion) which were moderate contracture (58.79±2.9 & 52.13±20.15) pre rehabilitation program then improved gradually to mild contracture level post 3 week (56.65±3.23 & 50.27±19.68) and vast improvement in follow-up phase post 6 weeks (59.15±2.25 & 51.71±20.09) with statistically significant difference in flexion ROM only P= <0.05.

In relation to, (MCP) joint ROM mean scores in the three rehabilitation program phases, the study demonstrated moderate contractures level in the hand joints (flexion & extension ROM) pre – program application (87.5±4.09 & -0.36±1.89) respectively, which gradually improved to mild contracture level post 3 week (85.73±5.09 & -1.02±2.22) respectively & and vast improvement post 6 week (89.46±1.9 & -0.43±1.91) respectively with statistically significant difference P = <0.05 in flexion ROM only.

Also, concerning to Inter phalangeal joint (proximal) joint ROM mean contracture score; the present study showed gradually improvement from moderate to mild contracture) in flexion & extension ROM mean score post 3 week (96.03±5 & -0.79±1.42) respectively. And good improvement post 6 week of program application (98.79±1.2 &

0.25±1.14) respectively with statistical significant difference in flexion ROM only p. value = <0.01

Furthermore, the study verifies decrease the severity of contractures from moderate to mild in patient as regarding Carpometacarpal joint ROM mean score only in flexion post 3 after physical rehabilitation program (67.91±2.48). Which gradually improve post 6 weeks after physical rehabilitation program (68.87±1.81) respectively with statistical significant difference p. value = <0.05

Table (4): Reveals negative correlation between wrist joint flexion and TBSA post 3 week of rehabilitation program application with no significant correlation

(P = -0.130). While, in follow-up (after 6 weeks), the study outlines that there was a statistically significant correlation between wrist joint flexion & TBSA (P= 0.449*). Also the study verifies negative correlation between MCP joint flexion and TBSA post 3 week of rehabilitation program application with no significant correlation (P= -0.431*) . Also the study shows that there was a statistically significant correlation between Interphalangeal joint (distal) & Carpometacarpal Joint in flexion with TBSA post 3 weeks of program application.(P= .635** & -0.734**) respectively and hospital stay by percent of (P= -0.433** & 0.525**)

Discussion:

Physical rehabilitation of hand burn begins on patient admission; each patient requires a specific plan for ROM exercises . The rehabilitation care plan typically evolves during the acute care period and during the months following injury. Burn injuries in hands are complex and the appearance of contractures is a common complication. The aim of physical rehabilitation program is to maintain mobility, prevent the development of the contracture and to promote the functionality of hand and good cosmetic results (Rrecaj et al., (2020)

Regarding demographic parameters of the studied patients: the information of this study indicated that most of them were in the young adult age group, with mean age was (31.3±13.1) years old. This result is similar to the study conducted by Kumar et al., (2019) who mentioned that the mean age of patients was, (31.3±18) years.

As regarding to gender; the present study showed that more than half of the studied patients were males; this is inconsistent with the study conducted by William et al., (2020): who found that more than half of the studied sample were females aged between thirteen to less than fourteen years. Also, the study result disagrees with the study conducted in the burn unit of Al Ahrar Hospital in Zagazig, Sharkia Governorate, conducted by Magdy et al., (2016)

who stated that more than half of studied sample were females. From researcher's point of view this difference is due to the fact that the nature works of majority of the patient in current study were working in industrial and professional work using hands which makes them more vulnerable to burns.

In relation to marital states; the present study revealed that the highest percentages of studied patient were married. This study's findings matched the study conducted in Assiut University Hospital's burn and plastic surgery department by **Ahmed, (2018)**, who revealed that the highest percentage of patients were married. As regard to hospital stay; the present study showed that the mean hospital stay of studied patients was (25.8±15) days; this is in the same line with the study performed by **Yangi & Wang (2021)** who found that the mean hospital stay was (24.3±22) days. But this study disagreed with **Najibe et al., (2019)** who verified that the mean length of hospital stay was (13.69 ± 12.78) days. From the researcher's point of view; the difference in length of hospital stay between patients is depending on various factors such as age, presence of concomitant medical problems, causative agent of burn, percent & degree of burn, mechanism of wound healing & nutritional statuses.

Regarding medical data: the result of the present study revealed that the lowest percentage of studied patients had diabetes mellitus and hypertension. This finding supported by **Yangi & Wang (2021)** who stated that a few of the study subjects suffered from diabetes. Also, in an agreement with the result of the study conducted by **Dolp et al., (2019)** who mentioned that the lowest percentage of burn patients admitted to the burn unit had diabetes mellitus.

The present study verified that the thermal injuries majority of the studied patients were flames, followed by scalds, this agrees with study carried out by **Majid et al., (2020)** Who explored that every year; only thermal fire-related burns were the most common causes of burn and accounted for over(300,000) deaths in the world. This result was supported by **Muhammad et al., (2018)**, who reported that, flame burns were the commonest type among all age group and both gender, followed by scalds. Furthermore, the current study finding agrees with the study done by **Thittamaranahalli et al., (2019)**, who explained that flame injuries contributed to the majority of burn cases. In addition to the studies done by **Doni & Winsen (2020)**, & **Mojgan et al., (2020)**, they said that the etiology of burn injury was flame for above two third and scald for one third of cases.

In the category of distribution of studied patients as regarding to their hand burn severity (HABS) ; the present study demonstrated that half of the studied patients were represented by Zone (A) Distal (MCP)

joint, followed by Zone (B) Over (MCP) joint , but the minority Zone (C) proximal (MCP) joint , this is in the same line with the study conducted by **Nestor et al., (2020)** who stated that patients who suffered from thermal hand burns were at a high contracture risk in zone A but disagrees with the study conducted by **Behm et al., (2016)** who verified that the wrist was the most frequently affected joint post thermal burn with statistically significant predictors of contracture development . From the researcher's point of view this may be due to multiple cutaneous functional units, percent, or contracture risk areas, site and number of affected joint within the dominant or non-dominant hand after thermal burn event.

According to the study findings, the majority of the study patient had second-degree burns, while the minority had third-degree burns. This agrees with **Hassan et al., (2018)**, who found that more than half of the patients had second-degree burns rather than third-degree burns. In all hand burns cases, with more than half had burns just in the hands and /or wrists and less than quarters were having burns solely in the forearm. Similar to study finding of **Al Laham et al., (2018)** which in the same line as they pointed that more than thirds of burnt patient injuries were of the second degree burn.

Regarding effect of range of motion exercise program;

The present study revealed that hand affected joints function for patient with thermal burn was moderate limited & moderate contracture compared to the normal anatomical average angle before burn injury; The present study revealed that the wrist joint ROM mean scores in (flexion & extension motion) which were moderate contracture pre rehabilitation program then improved gradually to mild contracture level post 3week and good improved in follow-up phase post 6 weeks . This current study finding agrees with the study conducted by **Chen (2017)** who reported that most of the studies patients had the affection mostly on flexion and extension of wrist joint ROM and improved gradually to mild contracture level with regular compliance of ROM rehabilitation program Also, in the same line with the studies conducted by **Dunpath et al., (2016)** & **Williams et al., (2018)**, who mentioned that, different hand ROM exercises programs used as an intervention that aimed to improve the joint mobility and strength of the hand and therefore, improving contracture level & functional ability. Also, such intervention helped patients to perform their daily activities independently and increasing the strength of handgrip by smoothly flexion and extension. And agree with the study conducted by **Mohamed et al., (2019)** who verified that a statistically significant improvement in range of

motion (flexion and extension) of hand joints post thermal burn mostly in the deep second and third degree burn included wrist joint.

In relation to mean score of (MCP) joint ROM in the three rehabilitation program phases, the study demonstrated that a moderate contracture in (flexion & extension ROM) mean score pre – program, which gradually improved to mild contracture level post 3 week & 6 week, this is in complete agreement with the study conducted by **Coupier et al., (2016)** who mentioned that values for flexion contracture score and extension score of the MCP joint had improved with frequency demonstrations and repetition active ROM exercise. In addition, the present study finding agrees with the study result carried out by **Mohamed et al., (2019)** who mentioned that ROM therapy was beneficial in recovery of (MCP) joint flexion function, maintaining existing joint and soft-tissue mobility, minimizing the effects of contracture hand joint formation, assisting neuromuscular re-education, and enhancing synovial movement of the joint.

In our study it was found that moderate contractures level in joint hand flexion was more occurrence in MCP, Interphalangeal joint (proximal & distal) joint in pre ROM exercise program application, this flexion contracture release to mild contracture level by sufficient ROM repetition each exercise for each hand joints 10 times three times a day until hospital patient discharge in most cases of moderate contracture due to thermal burns. This agree with the study conducted by **Subbu & Raman (2019)** who mentioned that patients who had undergone joint hand flexion contracture release gradually followed with regular physiotherapy and splinting had very good functional recovery of hand joint.

The result of the present study reported that there was a statistical significant difference as regard patient contractures mean scores in relation to Interphalangeal joint (distal) between pre & post (3 & 6 weeks) from implementation of physical rehabilitation program from moderate limited & moderate contracture to mild contracture level. Likewise **Ardebili et al., (2018)** supported the result as they demonstrated that significant improvements in ROM for Interphalangeal joint function balance from admission to discharge.

From the researcher's point of view: rehabilitation program management provided by therapists & professional nurse within first 3 weeks post-thermal burn injury assisted the patient to attain an anticontracture position, followed by daily repetition of active -passive ROM exercises and dynamic/static splints that performed under the rehabilitation therapists' professional guidance. All of these helped to improve the level of contracture severity in

the hand joint, from moderate to mild level after three weeks, and then to complete recovery after six weeks from physical rehabilitation program demonstrations.

Furthermore the study revealed negative correlation between wrist joint flexion and TBSA area, post 3 week of rehabilitation program application with no significant correlation. While, in follow-up (after 6 weeks), the study outlined that there was a statistically significant correlation between wrist joint flexion & TBSA

This agrees with **Won et al., (2016)** who mentioned that the majority of the study sample (patients) had symptoms of aggressively and rapidly progressing hand swelling, as the hands had a deep partial-thickness (second-degree deep) burn and full-thickness (third-degree) burn.

Also, the current study showed that there was a statistically significant correlation between Carpometacarpal Joint in flexion with TBSA and hospital stay in post 3 & 6 weeks of program application. This is in the same line with the study conducted by **Jianglin et al., (2019)** who verified that the Carpometacarpal joint was the most commonly affected joint followed by the proximal joint. This is related to a predictor of the presence of contractures due to the length of hospital stay, concomitant medical problems & total body surface.

From the researcher's point of view; the risk of contracture is higher when thermal burns occur on the flexor side of a joint or limb. This is because the most comfortable position is a flexed position; moreover, flexor muscles are normally stronger than extensor muscles, thus if an extensor burn occurs, patients can use the flexors' strength to stretch the affected area. The flexed position is the functional position, such as clasping the hand. So the measurement of finger and wrist range of motion (ROM) for patient with thermal burn is a great importance to all health care providers when assessing functional outcomes of exercises program.

Conclusion:

The findings of the study backed up the research hypotheses:

Significant improvement in hand joints range of function among patient with thermal burn patients post physical rehabilitation program application.

Recommendations:

- Using new physical rehabilitation modalities as Smart Glove that can be operated only through active ROM movement for patients with burn hand.
- Comparative study of hand rehabilitation outcomes for patients having fourth-degree burns with different types of burn injuries.

- Efficacy of different physical therapy methods on actively daily living for thermal burn patient.
- Effect of anti-contracture positioning and splinting on hand joint function & contracture severity.

References:

- **Ahmed Z.R., (2018):** Risk Factors of Abdominal compartment syndrome during Resuscitation Phase of Burned Patient. Master degree, Critical department, Faculty of nursing, Assiut University, Vol. 6, No. 15, P.P 169-178
- **Al Laham N., Elmanama A., & Tayh G., (2018):** Possible Risk Factors Associated with Burn Wound Colonization in Burn Unit of Gaza Strip Hospitals, Palestine, Annals of Burns and Fire Disasters, Vol. (26), No. (2), P.P 68-75.
- **Ardebili M.F., Manzari S.Z., & Bozorgnejad M. (2018):** Effect of educational program based on exercise therapy on burned hand function, Vol. (3), No. (1), P.P 39-46
- **Bache S., Connor E., Theodora k., Quentin F., Bruce P., & Peter D. (2017):** Hand Buren Severity Vol., 43, No, 1, P.P 93-99
- **Bayuo, J., Agbenorku, P., & Amankwa, R. (2016):** Study on acute burn injury survivors and the associated issues. Journal of Acute Disease, Vol. 5, No. (3), P.P 206 –209.
- **Behm D.G., Blazeovich A.J., Kay A.D., & McHugh M. (2016):** Acute Effects of Muscle Stretching on Physical Performance Range of Motion, and Injury Incidence in Healthy Active Individuals: A Systematic Review. Appl Physiol Nutr Metab. Vol.41, No. (1), P.P 1-11.
- **Chen Z. (2017):** The effect of a rehabilitation intervention model on improving the comprehensive health status of patients with hand burns. International journal of burns. Vol. 43, No. (4), P.P 877-885.
- **Couplier J., Hamoudi S., Telese-Izzi S., Feipel V., Rooze M., & Van Sint J., (2016):** A novel method for in-vivo evaluation of finger kinematics including definition of healthy motion patterns. Clin Biomech (Bristol, Avon). Vol. 31, P.P 47-58.
- **Daffue B., Moolman D., Ferreira S., Roos L., Schoeman L., Smit S.J., & Joubert G. (2019):** the causes of burn wounds among adult patients treated at Pelonomi Tertiary Hospital, Bloemfontein, general surgery, Vol. (56), No. (3), P.P31-36.
- **David M.K. (2016):** Basic anatomy and biomechanics of the hand and how these relate to hand examination and assessment of injury emergency Nurse. Vol.14, No.6, p.p 26-37.
- **Deng, Y.T., Zhang, Z. R., Fu, Q. R., Zheng, Y. H., Cao, X. M., & Chen, Q. X. (2017):** Evaluation of effectiveness in a novel wound healing ointment-crocodile oil burn ointment. African Journal of Traditional, Complementary and Alternative Medicines, Vol.14, No. (1), P.P 62–72
- **Dolp R., Rehou S., Pinto R., Trister R. & Jeschke G. (2019):** The effect of diabetes on burn patients: a retrospective cohort study, Vol. (23), No. (1), P.p 1-10.
- **Doni S. & Winsen H. (2020):** Epidemiology and Characteristics of Burn Patients in Dr. Soedarso General Hospital during 2017 – 2020: Retrospective Study, Clinical Sciences / Surgery, Vol. 9 No. B (2020)
- **Dunpath T., Chetty V., & Reyden D. (2016):** Acute burns of the hands–physiotherapy perspective. African health sciences. Vol.16, No (1), P.P 266-75.
- **Faisal A., Amjad A. & Zehra N., (2016):** Impact of facial burn injury on self esteem of burn patients– a hospital based study from Karachi. J Dow Uni Health Sci, Vol (10), No (1), P.P 25-30.
- **Faris H. & Al Naser K.R., (2019):** Epidemiological characteristics of burn injuries in Iraq: A burn hospital-based study, Burns, Vol. (45), No. (2), P.P 479-483.
- **Hassan Z., Mullins R.F., Alam B., & Mian M.H., (2018):** Carpal Tunnel Syndrome Following Burn, Annals of Burns and Fire Disasters, Vol.(20), No.(3) , P.P 153-155
- **Honnegowda M.T., Kumar P., Udupa P. & Rao P., (2019):** Epidemiological study of burn patients hospitalized at a burns center, Manipal. Int wound, Vol. (16), No. (1), P.P 79-83.
- **Hosseini S.N., Rashtchi V., Kamali K., & Moghimi M.H. (2017):** Epidemiology and outcome of 2,590 burned patients in Northwest Iran. Annals of Burn and Fire Disasters, Vol. (30), No. (2), P.P 85-90.
- **Hoyune E., Sandra V., & Kevin C. (2019):** Outcomes Following Replantation & revascularization in the Hand, "Hand Clin" Vol. 35, No. 2, P.P 207-219
- **Jeffrey C. Schneider M.D., Radha H., Phala H. , Richard G., & Karen K. (2006):** Contractures in burn injury: defining the problem. J Burn Care, Vol. (27), No.(4), P.P 508–514.
- **Jianglin T., Jian C., Junyi Z., Huapei S., Huan D., Ming A., Gaoxing L., & Jun W. (2019):** Joint contractures in severe burn patients with early rehabilitation intervention in one of the largest burn intensive care unit in China: a descriptive analysis Burns Trauma. Vol. 7: P.17.
- **Kelly M.B., Berenz T.Y., & Williams T. (2019):** Orthoses for the burned hand, upper limb orthoses. Atlas of orthoses and assistive devices E-book, chapter (15), section (3), 5th Ed, Elsevier Inc, P.172.

- **Kumar P., Udupa P. & Rao P. (2019):** Epidemiological study of burn patients hospitalized at a burns center, Manipal. *Int. wound*, Vol. (16), No. (1), P.P 79-83.
- **Lewis, E., Fors, L., & Tharion, W. (2010):** Interrater and intrarater reliability of finger goniometric measurements. *American Journal of Occupational Therapy*, Vol.64, P.P 555–561
- **Li L., Dai J. X., Xu L., Huang Z. X., Pan Q., Zhang X., & Chen Z. H. (2017):** The effect of a rehabilitation intervention model on improving the comprehensive health status of patients with hand burns. *International journal of burns*. Vol. 43, No. (4), P.P 877-885.
- **Magdy H.A., El-Maghawry M., El Nem W.A., Abd-Allah S., & Hagag S.A., (2016):** An interventional study to decrease healthcare associated burn wound infections in the burn unit of Al Ahrar Hospital in Zagazig city, Sharkia Governorate, *International Journal of Current Microbiology and Applied Sciences* Vol. (5), No. (3), P.P566-578.
- **Majid K.R., Hosein A. , Ahmad A. , Hassan T.A., & Saeid E., (2020):** Epidemiology of severe burns in North-East of Iran: How is the burn size different in a developing country from developed ones "Ann Burns Fire Disasters" Vol. 4, No. (1), P.P 4-9
- **Mohamed M., Ereny S., & Mohamed S., (2019):** Efficacy of exercise combined with music on pain and range of motion in pediatric lower limb, *Burn The Medical Journal of Cairo University.*, Vol. 87, No. 7, P.P 4103-4107
- **Mojgan L., Ahmad M., Babak D., Mohammad K., Hanieh A. & Mohammad A., (2020):** Development of nursing care guideline for burned hands, *National Institute of health , "Nurs Open"* Vol.7, No. (4), P.P 907–927.
- **Muhammad S., K., Muhammad R., Usman A., & Tariq I. (2018):** Epidemiology of Burns: A Decade Experience. *JSM Burns and Trauma*. Vol. 3, No. (2), P.1042.
- **Najibe M., Abdolreza J., Fatemeh G., A., Azadeh A., M., Maryam G., Marzieh A., K., Fatemeh R., & Mohsen A. (2019):** Demographic characteristics of burn injuries refer to burn center of Northern, Health Science Research Center, Addiction Institute, Mazandaran University of Medical Sciences, Sari Iran Vol.6 , No. 3,P.P 144-148
- **Nestor J. Jarque B., &Manfredo A. (2020):** A large calibrated database of hand movements and grasps kinematics ,*Scientific Data*, Vol. 7, No. (12), P.4
- **Norkin C.C., &White D.J., (2009):** Measurement of Joint Motion: A Guide to Goniometry, introduction Goniometry as basic concepts, Philadelphia: Spiral Bound, FA Davis; Chapter (1), 4 th Edition, P.P 30-60
- **Rrecaj S., Hysenaj H., Martinaj M., Murtezani A., Ibrahim K., Haxhiu B., & Buja Z. (2020):** Outcome of physical therapy and splinting hand burn injury. *Materia Socio-medica*. Vol.27, No. (6), p.380.
- **Schneider J.C., Holavanahalli R., Helm P., Goldstein R., & Kowalske K., (2006):** Contractures in burn injury: defining the problem. *J Burn Care*, Vol. (27), No. (4), P.P 508–514.
- **Serghiou M.A., Niszcak J., Parry I., & Richard R (2016):** Clinical practice recommendations for positioning of the burn patient. *Burn*. Vol.42, P.P 267–275.
- **So- Young J., Yoon S., Seung Y., Hyun S., & Cheong H., (2020):** Effects of Virtual Reality-Based Rehabilitation on Burned Hands: A Prospective, Randomized, Single-Blind Study *J Clin Med*. Vol.9 ,No.(3) P.731
- **Sorkin M., Cholok D., & Levi B. (2017):** Scar Management of the Burned Hand. *Hand Clin*. Vol.33, P.P 305–315.
- **Stratton S., (2019):** Quasi-Experimental Design (Pre-Test and Post-Test Studies) Pre-hospital and Disaster Medicine , Vol. 34 , No (6) , p.p 573 – 574
- **Subbu P. & Raman G. (2019):** Post burn flexion contracture of hand: a prospective study *International Surgery Journal* , Bai SPL Int Surg J Vol.6 No.(8): P.P 2823-2827
- **Thittamaranahalli M., Pramod K. , Padmanabha U., & Pragna R. (2019):** Epidemiological study of burn patients hospitalized at a burns center, Manipal Vol.16 , No.(1), p.p 79-83
- **William S., Kyle B., & Ashley W., (2020):** Safety of Early Postoperative Range of Motion in Burn Patients with Newly Placed Hand Autografts: *Journal of Burn Care & Research*, Vol. 41, No. 4, P.P 809–813
- **William S., Dewey, P.T, Kyle B., Sarah K., Kaitlin A., Pruskowski, C., Ashley W., & Julie A.,S (2020):** Safety of Early Postoperative Range of Motion in Burn Patients With Newly Placed Hand Auto grafts: A Pilot Study *Journal of Burn Care & Research*, Vol. 41, No.(4), P.P 809–813
- **Williams M.A., Srikesavan C., Heine P.J, Bruce J., Brosseau L., Hoxey T., & Lamb S.E. (2018):** Exercise for rheumatoid arthritis of the hand. *Systematic Reviews*. *Cochrane Database Syst Rev* Vol.31, No. (7), P.7
- **Won Y., Soo J., So Y. J., Ki U., & Cheong H., (2016):** Effects of a Modified Hand Compression Bandage for Treatment of Post-Burn Hand Edemas *Annals of Rehabilitation Medicine* Vol.40, No. (2), P.P 341-350.

- **World Health Organization (WHO) (2021):** Rehabilitation program <https://www.who.int/news-room/fact-sheets/detail/rehabilitation> 10 November 2021
- **Yangi B., & Wang X., (2021):** The impact of diabetes mellitus on mortality and infection outcomes in burn patients: a meta-analysis European Review for Medical and Pharmacological Sciences Vol. 25, P.P, 2481-2492
- **Yong D., Guo-Zhong L.v., Shun Y.,u., Dan W., & Qian T. (2020):** Long-term medical treatment of patients with severe burns at exposed sites, "World J Clin Cases" Vol. 8,No. (16), P.P 3515–3526.