

Effect of Mirror Therapy on Complex Regional Pain Syndrome Post Wrist Burn in Children with Type I Diabetes: A Randomized Controlled Trial

¹Mina Nashat Halim Farag, ²Wagdy William Amin Younan,
³Emad Makram Ghattas, ⁴Marwa Mahmoud Mahfouz Mahmoud

Abstract--

Background: Studying of mirror therapy training in complex regional pain syndrome on type I diabetic children is a strategy for determining its efficacy in reducing degree of pain and increase in hand grip and pinch strength

Objective: To evaluate the effectiveness of mirror therapy on complex regional pain syndrome (CRPS) post wrist burn in children with type I diabetes and prevent worsening of the case by neurological complication for diabetes

Methods: Thirty diabetic children with CRPS post wrist burn with age ranged from 10 to 16 from both genders participated in this study. Children divided randomly into two groups (A & B) of equal number, fifteen children each. All individuals assessed in our study using VAS to assess the degree of pain and using baseline handheld dynamometer to assess hand grip and pinch before starting the treatment protocol and 4 weeks after starting the treatment program.

The treatment protocol used for the two groups include: children in study Group (A) received conventional hand progressive exercise program (active, and active resisted hand exercises) for 15 min in addition, the same exercises were done by the sound hand in front of mirror for 15 min. Group (B) received only conventional hand progressive exercise program for 30 min. Both groups participated in 12 sessions and the overall times assigned in both groups are the same

Results: This study revealed statistically significant differences in decrease degree of pain and increase in hand grip and pinch strength, in mirror group than control group. (P value < 0.01)

¹Department of physical Therapy for cardiopulmonary disorders and geriatrics- Faculty of Physical Therapy – Deraya University, Minia, Egypt.

²Colonel physiotherapist at physical therapy department sector of medical services, ministry of interior Department of physical Therapy for disturbance of growth and development in pediatric and it is Surgeries- Faculty of Physical Therapy – Deraya University, Minia, Egypt.

³Department for integumentary- Faculty of Physical Therapy – Deraya University, Minia, Egypt.

⁴Department of Basic Science- Faculty of Physical Therapy – Deraya University, Minia, Egypt.

Conclusion: *From the finding of this study we concluded that mirror therapy exercise program is an effective, safe, relatively inexpensive, simple, and available modality in decreasing pain and improving function level.*

Key words--*Type I diabetic children, complex regional pain syndrome (CRPS), visual analogue scale (VAS), Handheld Dynamometer*

I. INTRODUCTION

Diabetes mellitus is a disorder of the metabolic homeostasis controlled by insulin, resulting in abnormalities of carbohydrate and lipid metabolism. Type I diabetes (also called juvenile-onset diabetes mellitus and insulin-dependent diabetes mellitus) is caused by an absolute insulin deficiency, the result of a loss of the insulin-producing beta cells of the pancreas (1)

Autoimmune type 1 diabetes constitutes 5%-10% of subjects diagnosed with diabetes (2) and is due to destruction of β cells of the pancreas (3)

The incidence of CRPS both type 1 & 2 are about 1% to 15%. It appears to be higher occurrence of CRPS in females. The ratio of female: male is 3:1. The affected age group is between 18 and 71 years with a mean age of 41.8 years. CRPS can also occur in children. Children with diabetes have highest incidence of CRPS as compared to non-diabetic children (4)

Diabetes mellitus (DM) is commonest endocrine disorder that affects more than 100 million people worldwide (6% population). It is caused by deficiency or ineffective production of insulin by pancreas which results in increase or decrease in concentrations of glucose in the blood. It is found to damage many of body systems particularly blood vessels, eyes, kidney, heart, and nerves (5)

In addition to diabetes, insulin resistance has many manifestations that include obesity, nephropathy, essential hypertension, dyslipidemia (hypertriglyceridemia, low HDL, decreased LDL particle diameter, enhanced postprandial lipemia and remnant lipoprotein accumulation), ovarian hyperandrogenism and premature adrenarche, non-alcoholic fatty liver disease and systemic inflammation (6)

Complex regional pain syndrome (CRPS) is debilitating condition, characterized by pain in limb, in association with sensory, vasomotor, sudomotor, motor and dystrophic changes. It commonly arises after injury to that limb. Pain is typically the symptom of CRPS but is often associated with limb dysfunction and psychological distress. Patients frequently report neglect – like symptoms or a feeling that the limb is aliens (7).

In children less than 18 years of age, complex regional pain syndrome (CRPS) type 1 develops most commonly in girls, with the incidence rising at or just before puberty. The lower extremity is more commonly

affected than the upper, with a ratio of about 5:1. Type 1 CRPS seems to be more common among Caucasian children (8).

CRPS can be divided into two types based on the absence (type 1, much more common) or presence (type 2) of a lesion to a major nerve. The sub type of CRPS has no consequences for the general approach in CRPS 2 should always be clarified – urgently in acute cases (9)

Mirror therapy suggests that visual illusion may enhance activity in primary motor cortex, then increasing the descending neural drive from the brain to muscles, viewing the illusion of functional practice upper limb in a mirror seemed to have an immediate effect on motor unit recruitment (10) .

Patients with chronic pain issues anticipate movements to be painful, mirrors help deceive them into thinking that they are not experiencing pain via dynamic feedback to their brains. (11). the use of the mirror gives the patient the "impression of having two normal limbs (12).

The current study aimed to determine the effectiveness of mirror therapy on complex regional pain syndrome (CRPS) post wrist burn in children with type I diabetes and prevent worsening of the case by neurological complication for diabetes

There is limited research studying the effect of mirror therapy on complex regional pain syndrome (CRPS) post wrist burn in children with type I diabetes and there is no research studying its intermediate effect. Did mirror therapy reducing degree of pain and increase in hand grip and pinch strength in children with type 1 diabetes?

II. MATERIALS AND METHODS

Study design

The design of the study was pre-test post-test randomized controlled trial design. The procedures followed agreed with the Institutional Ethical Committee Clearance, and written informed consent was taken from their legal guardians of the children.

Participants

This study was conducted in the laboratories of faculty of physical therapy Cairo University and police force hospital from March to October 2019 with simple random sample. Thirty type I diabetic children with ages ranged from 10 to 16 years old of both sexes were randomly selected from comprehensive rehabilitation center and assigned randomly into two equal groups (15 children each). All participants were included to this study if they had 2nd degree burn, type I diabetes mellitus, children with only one wrist burn and with CRPS (type1). Participants with any neurological deficits such as neuropathy, convulsions, involuntary movements or receiving muscle relaxants, children with impairment of sensation (superficial, deep and cortical), Patients with hand deformities, Visual impairments, Open wound, Patients with poor general health were excluded from the study.

Intervention

Children's in study Group (A) consisted of 15 children (11 B and 4G) were received conventional hand progressive exercise program (active, and active resisted hand exercises) for 15 min in addition, the same exercises were done by the sound hand in front of mirror for 15 min. Children's in control Group (B) consisted of 15 children (10 B and 5G) were received only conventional hand progressive exercise program for 30 min.

Procedures

a) Assessment procedures: The assessors were blinded folded to group allocation.

1-Hand held dynamometer

Hand-held dynamometry (HHD) is a reliable and valid assessment tool. The strength of both hand grip and pinch was assessed with HHD (Base line pneumatic bulb made in U.S.A.). This dynamometer is a portable digital instrument than can be held in the palm of the hand giving muscle strength measurements in kilogram-force (kg). It was used to evaluate the hand function before the treatment (Pre-treatment) and at the end of the treatment (after 1 month).

The measurement was conducted according to standard procedures recommended by the American Society of Hand Therapists (ASHT). The participants sat upright on a height-adjustable chair with their feet supported. The tested arm was positioned on a table with the shoulders slightly abducted ($\sim 10^\circ$) and neutrally rotated, the elbow in 90° of flexion, the forearm in 0° between pronation and supination, and the wrist in neutral resting position. The patient was instructed to perform maximal isometric contraction. The test repeated 3 times with 30 sec relaxation period in-between and the average value of 3 tests used for the analysis. The participants were instructed to maintain that position during the test (13).

2-Visual analogue scale:

Visual analogue scale is considered the 'gold standard' technique and is used particularly in pain related research. It is consisted of a 10-cm line marked 'no pain at one end and 'pain as bad as it could be' at the other (14).

Horizontal line, 100mm in length anchored by word descriptors at each end. The VAS score is determined by measuring in millimeters from the left-hand end of the line to the point that the patient marks (15). Each patient was asked to mark on the line at the point that they feel represents their perception of the current state. Assessment was done before and after one month of treatment.

b) Training procedures

I-Group A (study group) received progressive exercise progra. (wrist flexion, extension, fingers flexion, extension, abduction and adduction exercise, thumb Opposition, Squeezing a ball by full hand , squeezing a ball by thumb and index , catch pins) in addition to mirror therapy exercise program. This

program was done in approximately 30 minutes, three times per week for 4 successive weeks (15 min for progressive exercise and 15 min for mirror therapy)

Mirror therapy

Mirror box consists of a 2 x2 foot mirror vertically propped up sagittal in the middle of a rectangular box. The top and front sides of the box are removed (16).

Mirror exercises included the following:

- Wrist flexion and extension.
- Fingers flexion, extension, abduction, and adduction.
- Squeezing a ball by full hand.
- Squeezing a ball by thumb and index finger.
- Catching pins with sound hand.

All exercises were done in front of the mirror while the patient was looking at his hand reflection.

II- Group B (control group) received only progressive exercise program. This program was done in approximately 30 min, three times pre week for successive 4 weeks. Both groups participated in 12 sessions and the overall times assigned in both groups are the same

In real life, young people with diabetes have variable blood glucose response to exercise. The blood glucose response to 60 minutes of intermittent exercise is somewhat reproducible within in a child if the timing of exercise the amount of insulin and the pre exercise meal remain constant (17).

It is especially important to plane for long duration or intense aerobic exercise or else hypoglycemia is almost inevitable early all forms of activity lasting more than 30 minutes will be likely to require adjustment to food and/or insulin (18).

Statistical analysis

Results were expressed as mean $\pm$ standard deviation (SD) for normally distributed data. Comparison of different variables between groups was performed using unpaired t test in normal distributed data. Pair-wise comparison (pre- versus post-assessment) within the same group for different variables was performed using paired t test in normal distributed data Statistical Package for Social Sciences (SPSS) computer program (version 23 windows) was used for data analysis. P value ≤ 0.05 was considered significant.

III. RESULTS

Patients General Characteristics

This study compromised thirty participants which were randomly divided into group A and group B, both were equal in number. The analysis of baseline values between two groups as shown in table 1 revealed

that there were no statistically significant differences between both groups in the mean age and sex distribution ($p > 0.05$) (Table 1).

Table 1. Basic characteristics of patients in both groups.

Characteristics	Group A (n = 15)	Group B (n = 15)	P
Age (years)	12.93 $\pm$ 2.17	13.56 $\pm$ 2.33	0.42 NS
Sex distribution M	11 (73%)	10 (67%)	0.69 NS
F	4 (27%)	5 (33%)	

Data are presented as mean $\pm$ SD or number of patients. NS= non-significant.

Paired t test revealed that there was a statistical significant reduction ($p < 0.05$) in VAS and significant increase ($p < 0.05$) in hand grip strength and pinch strength at the end of the study compared to the beginning of the study at both groups. However, Independent t test showed that there was no statistical difference between the two groups in their all depend variables ($p > 0.05$) pre treatment, while there was a statistical significant reduction ($p < 0.05$) in VAS and significant increase ($p < 0.05$) in hand grip strength and pinch strength at post treatment in favors of group A in compared to group B ($p < 0.05$) (Table2).

Table 2. Mean values of all dependent variables in pre- and post-program at both groups.

		Group (A)	Group (B)	P value*
VAS	Pre-program	7.73 $\pm$ 1.33	7.46 $\pm$ 1.46	0.59 ^{NS}
	Post-program	3.2 $\pm$ 0.94	4.93 $\pm$ 1.48	0.001 ^{HS}
	P value**	0.001 ^{HS}	0.001 ^{HS}	
Hand grip strength	Pre-program	4.93 $\pm$ 1.17	4.46 $\pm$ 1.28	0.3 ^{NS}
	Post-program	6.88 $\pm$ 1.28	5.19 $\pm$ 1.09	0.001 ^{HS}
	P value**	0.001 ^{HS}	0.001 ^{HS}	
Pinch strength	Pre-program	2.98 $\pm$ 0.46	2.92 $\pm$ 0.73	0.78 ^{NS}
	Post-program	5.22 $\pm$ 0.96	3.9 $\pm$ 0.71	0.001 ^{HS}

	P value**	0.001 ^{HS}	0.001 ^{HS}	
--	------------------	---------------------	---------------------	--

* Inter-group comparison; ** intra-group comparison of the results pre- and post-program.

^{NS} P > 0.05 = non-significant, ^{HS} P < 0.01 = highly significant, P = Probability.

IV. DISCUSSION

The current study was conducted to explore the effect mirror therapy on complex regional pain syndrome (CRPS) post wrist burn in children with type I diabetes. The results obtained from this study clearly demonstrated the positive effects of using mirror therapy in addition to the physical therapy program in reducing degree of pain and increase in hand grip and pinch strength

Complex Regional Pain Syndrome is a relatively occurring after traumatic injury, and rarely after surgical procedures. Numerous studies have documented the development of Complex Regional Pain Syndrome following distal upper extremity procedures such as carpal tunnel release, Dupuytren's contracture release, and amputation. CRPS has also been described following minor trauma resulting in fractures, burns, and venipuncture; however, to the best of our knowledge there are no case reports documenting the development of CRPS specifically following trigger finger release in the current literature. A positive outcome to CRPS is favored when patients are treated early and from a multi-modality approach. Limited research is currently available for guiding appropriate therapy, and unfortunately while modest improvement can be achieved in some cases, significant disability frequently results (19).

Among children with diabetes, complications do not progress to the point that neuropathy would be of concern. Likewise, conditions such as postherpetic neuralgia, trigeminal neuralgia, radiculopathies, and complications of stroke are of extremely low incidence in young patients. However, some neuropathic conditions are becoming increasingly recognized in children and adolescents, including complex regional pain syndromes (CRPSs) (principally type 1), phantom limb pain, spinal cord injury, trauma and postoperative neuropathic pain, autoimmune and degenerative neuropathies (eg, Guillain-Barré syndrome, Charcot-Marie-Tooth disease), and the effects of cancer disease processes and treatment. Finally, some neuropathic pain syndromes that are rare are relatively unique to the pediatric population, including toxic and metabolic neuropathies (eg, lead, mercury, alcohol, infection), hereditary neurodegenerative disorders (eg, Fabry disease), mitochondrial disorders, and primary erythromelalgia (20).

Mirror therapy suggests that visual illusion may enhance activity in primary motor cortex, then increasing the descending neural drive from the brain to muscles, viewing the illusion of functional practice upper limb in a mirror seemed to have an immediate effect on motor unit recruitment (21).

Patients with chronic pain issues anticipate movements to be painful, mirrors help deceive them into thinking that they are not experiencing pain via dynamic feedback to their brains (22).

Moseley et al. stated that in chronic pain, a minifying mirror is thought to modulate the pain by changing the perceived size of the painful limb to be smaller, which also leads to the pain being perceived less. The painful limb is often felt enlarged in chronic pain therefore the minifying mirror might help establish a corrected body image. It is possible that the enlarging mirror only influence the body image, and not the body schema, which in the current study means that the effects is not reflected in changes in the motor system (23).

So this controlled randomized study was conducted to determine the effect of the mirror therapy on complex regional pain syndrome (CRPS) post wrist burn, the parameters investigated in this study were pain, hand grip and pinch strength.

In our study 30 children type I with CRPS post wrist burn received progressive exercise program for four weeks (3 session per week), while the study group in addition received mirror therapy exercise on the sound hand for 15 min in first 2 weeks and 30 min in the last 2 weeks. The results revealed significance improvement in all parameters in both groups following the treatment, however higher statistical results were achieved in the study group.

The percentage of improvement of VAS in groups A and B was 58.65% and 33.9% respectively, while in hand grip strength was 39.55% and 16.36% respectively. However, there was a significant improvement in VAS and hand grip in group A compared to group B ($P=0.001$), also we reported a significant increase in pinch strength as the percentage of improvement in groups A and B was 75.16% and 33.56% respectively with more significant improvement in group A compared to group B ($P=0.0001$).

Our study results come in agree with several studies (24-31). Yun and Kim.,(2019) observed a significant decrease in pain in both mirror therapy and control groups. However, comparing between the 2 groups showed a significant reduction (by 23.70%, $P=.04$) in pain within the experimental group than the control group. Thus, a synergic effect between the conventional physical therapy and MT might have been induced, leading to greater pain reduction effect in the experimental group. Also no significant difference in muscle elasticity between groups was observed. Therefore, it was suggested that patients with mutilating injuries who received MT along with conventional physical therapy showed significant improvements in hand function and pain reduction. After 4 weeks of mirror therapy, significant improvements in hand function and decrease in pain were observed for the experimental group. These results supported the primary hypothesis that mirror therapy would have positive effects on function recovery in patients with mutilating injuries (32).

Boesch et al. have shown that phantom limb and complex regional pain syndrome are significantly reduced (standardized mean difference =-1.11; 95% CI: -0.56 to -1.66; $P<.0001$) in meta-analysis of 2 randomized controlled trials (RCTs) on the effect of 4week-long mirror therapy, also Thieme et al. published a systematic review with a meta-analysis of data from eight RCTs (224 participants), including five additional RCTs to the previous review. Conditions included complex regional pain syndrome, phantom limb pain and

pain after stroke. Results indicated that mirror therapy reduced pain in the affected limb (standardized mean difference = -1.00; 95%CI -1.77 to -0.24; $p=0.01$) when compared with covered mirror, direct view of limbs, no treatment and repetitive transcranial magnetic stimulation.(25,26)

Park et al. concluded that mirror therapy showed positive effects on upper-extremity function and activities of daily living in chronic stroke patients. Differences in upper-extremity function after intervention in the mirror group were compared with those in the control group treated with sham therapy. The mirror group showed significantly greater differences compared to the control group, with improvements in paretic upper-extremity functions ($p < 0.05$) (27).

Wand et al. has applied a randomized controlled trials on the efficacy of mirror therapy for back pain, they placed one large mobile mirror in front of the participant and one mirror behind the participant so that there was a clear view of the reflection of their back. They found that pain intensity was reduced immediately post exercise compared with no reflection control during repeated lumbar movements (mean difference = 9.3 mm; 95%CI 2.8-15.7; $p=0.007$; 25 participants). The duration of low back pain elicited was also shown to be significantly reduced in the mirror condition (mean difference = 49.9 s; 95%CI 19.3-80.6; $p=0.003$) (29).

Cacchio et al. conducted a study to compare the effectiveness of mirror therapy on complex regional pain syndrome type I of upper limb in patients with acute stroke. The primary end points were a reduction in the VAS score of pain at rest, on movement, and brush-induced tactile allodynia. The secondary end points were improvement in motor function as assessed by the Wolf Motor Function Test and Motor Activity Log. The mean scores of both the primary and secondary end points significantly improved in the mirror group ($P < .001$). The result indicates that mirror therapy effectively reduces pain and enhances upper limb motor function in stroke patients with upper limb with complex regional pain syndrome type I. (30). Yavuzer et al. stated that patients with subacute stroke have improvement in hand functioning after using mirror therapy in addition to a conventional rehabilitation program compared with a control treatment immediately after 4 weeks of treatment and at the 6-month follow-up. The scores of the Brunnstrom stages for the hand and upper extremity and the FIM self-care score improved more in the mirror group than in the control group after 4 weeks of treatment (by 0.83, 0.89, and 4.10, respectively; all $P<.01$) and at the 6-month follow-up (by 0.16, 0.43, and 2.34, respectively; all $P<.05$)(31).

Fukumura et al. who reported that pinch and palmar grasp strength in study group were higher than that in control group although still non statistically significance difference which disagreed ,the illusion of a functional paretic upper limb in a mirror seemed to have an immediate effect on motor unit recruitment, since maximal grasp strength tests performed behind the mirror were highly significantly stronger than those performed with the paretic limb under direct visual control. This suggests that the visual illusion of mirror therapy may enhance activity in the primary motor cortex, thereby increasing the descending neural drive from the brain to the muscles. This is congruent with the three studies using transcranial magnetic stimulation that identified an improvement of primary motor cortex excitability in healthy participants observing their

movements in a mirror. Bimanual training improved hand strength significantly with trends towards a stronger effect of mirror training on grasp and of bilateral training on pinch (33).

Ramachandran & Rogers-Ramachandran conducted a study where primary aim was relief of pain in the affected limb, rather than improvement in paralysis or spasm that occurred for eight patients with CRPS type 1 who participated in this study, five had a marked reduction in pain at rest and on movement 6 weeks after regular use of the mirror device, and the remaining three reported no benefit (34).

V. CONCLUSION

Within limitation of this study the following conclusion was warranted the result of this study which supports the importance of using mirror therapy exercise program on complex regional pain syndrome post wrist burn in children with type I diabetes to decrease pain and improve pinch and hand grip.

From the finding of the current study we concluded that mirror therapy exercise program is an effective, safe, relatively inexpensive, simple and available modality in decreasing pain and improving function level.

Authors' Contribution

We are three authors for this work, and we did all requirement to accomplish this work, there is no other researchers participate in this work.

Competing interests: We did not receive any financial support from any institution or company it is our project and we insured all expenses. No competing interests

Source of funding: self-funding.

REFERENCES

1. **David W, Leslie P.** Type 1 Diabetes Mellitus in Pediatrics. *Pediatr. Rev.* 2008;29;374-385.
2. **Maahs D, West N, Lawrence J, Mayer-D.** Epidemiology of type 1 diabetes. *Endocrinol Metab Clin North Am* 2010; 39: 481-497 [PMID: 20723815 DOI: 10.1016/j.ecl.2010.05.011].
3. **Daneman D.** Type 1 diabetes. *Lancet* 2006; 367: 847-858.
4. **Siddiqui M, Siddiqui S, Ranasinghe J, Furgang F.** complex regional pain syndrom A clinical review. 2000; Volume 2 number 1.
5. **Ismail, M.** Clinical evaluation of antidiabetic activity of Trigonella seeds and Aegle marmelos Leaves, *Worl Appl Scien J.*, 2009; 7(10): 1231-1234.
6. **Kraemer F, Ginsberg H, Gerald M, Reaven M.** Demonstration of the central role of insulin resistance in type 2 diabetes and cardiovascular disease. *Diabetes Care* 2014; 37: 1178-1181.
7. **Ferttloh J, Huppe M. and Maier C.** severity & specificity of the neglect- like symptoms in patients with complex regional pain syndrome (CRPS) compared to chronic limb pain of other origins *Pain.* 2006; 124(1-2):184-9.
8. **Sherry DD, Wallace CA, Kelley C.** Short- and long-term outcomes of children with complex regional pain syndrome type I treated with exercise therapy. *Clin J Pain.* 1999 ;15:218–223.
9. **Harden R, Bruehl S, and Stanton HM.** Proposed new diagnostic criteria for complex regional pain syndrome. *Pain Med.* 2007; 8 (4) :326-331.

10. **Michielsen M, Smits M, Ribbers G, Stam H, Selles R, Bussmann J and Van der gesst J.** The Neuronal correlates of mirror therapy: an FMRI study on mirror induced visual illusions in stroke patients", *Journal of Neurology, Neurosurgery and Psychiatry*.2011; 82 (4): 393-8.
11. **Priganc V, and Stralka S.** Graded motor imagery. *Journal of Hand Therapy*.2011 ; 24(2) :164-8.
12. **McCabe C.** Mirror visual feedback therapy: a practical approach. *Journal of Hand Therapy*.2011 ; 24 (2) :170-9.
13. **Fess E, Casanova J.** Clinical assessment recommendations. 2nd. Chicago: American Society of Hand Therapists; 1992. Grip strength; pp. 41–45.
14. **Woodforde J and Merskey. H.** Correlation between verbal scale and visual analogue scale and pressure algometer. 1. psychosom. Res.1971; 16 173--178. 175-184.
15. **Wewers M, and Lowe N.** A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing and Health* .1990; 13 (4):227-236.
16. **Tample M, Bary O, Riddell M.** reliability and repeatability of blood glucose response to prolonged exercise in adolescent boys with IDDM. *Daibetic care*.1995;18 : 326-32
17. **Robertson K, Addlfsson P, Riddell M, Scheiner G, Hanas R.** exercise in children and adolescent with diabetes.2009; (10 suppl. 12) : 154- 168.
18. **Ramachandran V, and Roger-Ramachandran D.** Synaesthesia in phantom limbs induced with mirrors. *Proc R SocLond B BiolSci*.1996 ; 263(1369) : 37.
19. **Johnson E, Pierpont Y, Salas R, Naidu D and Payne D.** Complex regional Pain Syndrome following Trigger Finger Release" *The internet journal of health Surgery*.2008 ; 2 : 2.
20. **Gary A, Robert H, Dworkin, Elliot J, Alyssa A, Rolf D.**Neuropathic Pain in Children: Special Considerations. 2010; 85(3 Suppl): S33-S41.
21. **Michielsen M, Smits M, Ribbers G, Stam H, Selles R, Bussmann J and Van der gesst J.**The Neuronal correlates of mirror therapy: an FMRI study on mirror induced visual illusions in stroke patients", *Journal of Neurology, Neurosurgery and Psychiatry*.2011; 82 (4): 393-8
22. **Priganc V, and Stralka S.** Graded motor imagery". *Journal of Hand Therapy*.2011 ; 24(2) :164-.
23. **Moseley G, Alberto G , and Charles S.** Is mirror therapy all it is cracked up to be? Current evidence and future directions. *Pain*.2008; 138 (1):7-10.
24. **Yun D. and Kim M.** Effects of mirror therapy on muscle activity, muscle tone, pain, and function in patients with mutilating injuries A randomized controlled trial". *Medicine baltimore*.2019; 98 (17):15157.
25. **Boesch E, Bellan V and Moseley G.**The effect of bodily illusions on clinical pain: a systematic review and meta-analysis". *Pain* .2016;157 (3) : 516–29.
26. **Thieme H, Morkisch N, Rietz C, Dohle C and Borgetto B.** The efficacy of movement representation techniques for treatment of limb pain": a systematic review and meta-analysis. *J Pain*.2016; 17(2):167-80.
27. **Park J , Chang M , Kim MK and Kim H.** The effect of mirror therapy on upper-extremity function and activities of daily living in stroke patients", *J Phys Ther Sci*, Jun. 2015; 27(6): 1681–1683.
28. **Rostami HR, Arefi A. and Tabatabaei S.** Effect of mirror therapy on hand function in patients with hand orthopaedic injuries": a randomized controlled trial.*Disabil Rehabil*.2013 ;35(19) :1647–51.
29. **Wand B, Tulloch V, George P, Smith A, Goucke R and O'Connell N.** Seeing it helps: movement-related back pain is reduced by visualization of the back during movement". *Clin J Pain*.2012; 28(7) :602-8.
30. **Cacchio A, De Blasis E, Santilli V, Necozone S. and Di orio F.** "Mirror Therapy for Chronic Complex Regional Pain Syndrome Type I and Stroke". *The New England Journal of Medicine*.2009 ; 361(6):634-6.
31. **Yavuzer G, Selles R, and Sezer N, Bussmann J and Stam H.** Mirror therapy improve handfunction in subacute stroke: a randomized controlled trial. *Arch Phys Med Rehabil*.2008 ; 89 (3):393-398 .
32. **Yun D. and Kim M.** Effects of mirror therapy on muscle activity, muscle tone, pain, and function in patients with mutilating injuries A randomized controlled trial". *Medicine baltimore*.2019 ; 98 (17):e15157
33. **Fukumura K., Sugawara K., and Tanabe S.** Influence of mirror therapy on human motor cortex. *Int J Neurosci*.2007; 117(7) :1039-48.
34. **Ramachandran V, and Roger-Ramachandran D.** Synaesthesia in phantom limbs induced with mirrors". *Proc R SocLond B BiolSci*.1996 ; 263(1369) : 377-386.