SPORT TK-EuroAmerican Journal of Sport Sciences

https://revistas.um.es/sportk Online ISSN: 2340-8812

Received: **09/10/2023.** Accepted: **02/04/2024.** Published: **15/04/2024**

Efficacy of mirror therapy in improving hand function post flexor tendon repair

Mohamed Bayoumi Ibrahim Bayoumi [1, 2]*, Ahmed Mohamed Nagy Saleh [1, 3], Karim Ibrahim Saafan[1], Shaimaa Mohamed Ahmed Elsayeh[1]

[1] Department of Physical Therapy for Surgery, Faculty of Physical Therapy, Cairo University, Egypt.

[2] Department of Physiotherapy, Faculty of Allied Medical Sciences, Middle East University, Amman, Jordan.

[3] Department of Physical Therapy for Surgery, Faculty of Physical Therapy, October University for Modern Sciences and Arts (MSA), Egypt.

* Correspondence: Mohamed Bayoumi Ibrahim Bayoumi; mohamed.forever@yahoo.com

ABSTRACT

The aim of this study was to determine the efficacy of mirror therapy (MT) in improving the total active range of motion (AROM) of the affected finger, hand grip strength, and hand function in patients with flexor tendon repair (FTR) in zone II. The study was an open-label, parallel-group, randomized controlled trial. Thirty patients with zone II FTR, aged 20-45 years, were recruited and randomized into two equal groups: the MT group and the sham MT group. The intervention began in the fourth week post-operation, consisting of thirty minutes of MT or sham MT, three sessions per week for four weeks, in addition to the traditional physical therapy (PT) program. The total AROM of the interphalangeal (IP) joints of the affected fingers, hand grip strength, and hand function were assessed. After four weeks of intervention, the percentage change in total AROM was 25.7% in the MT group and 19.93% in the sham MT group. Additionally, hand grip strength and Michigan Hand Outcomes Questionnaire (MHQ) scores showed greater improvement in the MT group compared to the sham MT group ($p < 0.05$). Adding MT to the traditional PT program may be more effective than the traditional PT program alone in improving the AROM of the interphalangeal (IP) joints of the operated fingers, grip strength, and MHQ scores.

KEYWORDS

Mirror Therapy; Hand Function; Flexor Tendon Repair

1. INTRODUCTION

Outcomes after flexor tendon repair (FTR) have improved with modern treatment, but complications are still common like adhesion formation, tendon rupture, re-operation, triggering, and pully failure with tendon bowstringing (Lilly & Messer, 2006).

Due to its essential and complex role in many essential human everyday tasks, such as object grasping as well as transforming, hand function plays a vital role in upper extremity function. So, restoration of normal hand function is a crucial goal that is necessary as its dysfunction has a negative impact on the subject's normal life (Neumann, 2013).

Early physical therapy (PT) after FTR of zone II is important to improve healing, increase tensile strength, reduce adhesion, stiffness and deformity and early return of function and the balance between acquiring a sufficient ROM (range of motion) and tendon rupture prevention is a well-recognized problem throughout flexor tendon rehabilitation. Tendon ruptures account for 5% of patients in literature (Dy et al., 2012; Rrecaj et al., 2014).

Mirror therapy (MT) is a mirror neurons-based approach that focuses on the mental practice of body part movement. MT is a type of exercise used as a complement to traditional rehabilitation, as it allows patients' eyes into thinking their impaired limbs are moving normally by reflecting the motion of their unaffected limbs in the midsagittal plane. The primary motor cortex must be activated in order to mimic motor action, and this requires mental practice, preparation, as well as the activation of mirror neurons, all of which have a close relationship with visual processing areas (Kang et al., 2011; Matthys et al., 2009). MT has been used in rehabilitation widely. MT has been mainly investigated for pain relief as well as motor recovery after stroke (Thieme et al., 2016).

There are no previous studies in which this technique is applied in management of FTR to the author's knowledge. Also, the previous studies on flexor tendon repair focused on splinting and early active mobilization. Therefore, this study was conducted to observe and record the results of adding the motor imaginary in form of mirror therapy to the early active dynamic exercises and stretching exercises in improving the total active fingers range of motion of the involved finger, hand grip strength, and hand function in patients with FTR in zone II.

2. METHODS

2.1. Study Design and Participants

The study was an open label, parallel group, randomized controlled trial. Patients were randomly recruited from Al Kasr El Ainy Hospitals and Outpatient Clinic at Faculty of physical therapy, Cairo University, Giza, Egypt. The study was conducted between June 2022 and January 2023. The ethical committee of the Faculty of Physical Therapy approved the study (P.T.REC/012/003533), and it was prospectively registered at the Clinical Trial Registry (NCT05347940).

Prior to the study, the sample size was determined using (G*power version 3.1) with the parameters 90% power, -level 0.05, as well as effect size 0.5. A total of 30 patients from both genders participated in this study. They were informed in detail about the purposes, procedures, and the benefits of the study, and signed the written consent form before participation. They were randomized into two groups of equal number, the mirror therapy group and the sham mirror therapy group using computer-generated block randomization. The block size was four to eliminate selection bias and reduce the variability between the groups. Sealing opaque envelopes with sequential numbers allowed for a method of concealed allocation.

Patients were referred by the plastic surgeon who underwent flexor tendon repair in zone II and were assessed for their eligibility to join the study. Patients who met the inclusion criteria were enrolled. Male or female patients with age of 20-45 years and passed three days after their operation were selected. Patients' exclusion occurred if they had one or more of the following: more than one operated finger, additional zones or additional hand tendon injuries, repaired flexor pollicis longus, previous tendon rupture post-repair, open fractures, nerve injury, major vascular injury, crush injuries, or any cognitive disorders that hindered their active participation in the exercise program. Patients who refused to join the study, were excluded.

2.2. Intervention

All patients of both groups received the same postoperative medical treatment in the form of medications including pain killers and antibiotics, and dressings over surgical lines. Patients in both groups had the same post-operative traditional physical therapy program as following (Henry and Howell, 2020; Newington et al., 2021; Savage et al., 2005):

- **Phase (1): From the 3rd postoperative day to the 4th week postoperatively:** Patients were asked to wear their dorsal blocking cast.
- **Phase (2): From the 4th week to the 6th week postoperatively:** Active exercises in form of active wrist flexion with fingers extension, active wrist extension with gentle active fingers flexion such as a straight fist (flexion of MCP as well as PIP joints and extension of DIP joints), full fist (flexion of MCP joints as well as IP joints), and hook fist (flexion of IP joints as well as extension of MCP joints) alternatively. Each active exercise was performed at frequency of 15 repetitions, three times per day.
- **Phase (3): From the 6th to the 8th week postoperatively:** In the physical therapy visit at the 6th postoperative week, the cast was removed at all. The patients were asked to continue the previous exercises out of splint. The exercises began with the digits being moved through the subsequent five positions: Straight hand (extension of MCP joints as well as IP joints), hook fist (flexion of IP joints as well as extension of MCP joints), full fist (flexion of MCP joints as well as IP joints), table-top position (flexion of MCP joints as well as extension of IP joints), and straight fist (flexion of MCP and PIP joints were as well as extension of DIP joints). Active flexor tendon-gliding, each exercise was performed at a frequency of 15 repetitions, three times per day.
- **Phase (4): From the 8th to the 12th week postoperatively:** In the 4thphysical therapy visit at the 8th postoperative week, the patients were asked to continue the preceding exercises along with progressive stretching and strengthening exercises as described in the following: The patient stood in a side of a table and rested the affected hand palm and fingers over it. The patient then used his/her unaffected hand to extend MCP, PIP, and DIP joints of the affected finger against the table and ensured that position by placing the unaffected hand over the extended affected hand. The patient then started to perform progressive combined stretching exercises for the extrinsic flexors of the affected hand by extending the wrist of the affected hand gradually through bringing his/her arm up over the hand till the limit of feeling discomfort. The patient then maintained the stretch for 30 seconds then relaxes for same time and then repeats. The patient repeated the stretch cycles 3 times for 3 times/day.

The MT group got an extra 30 minutes of the MT program for the same time period. Patients sat at a table next to a vertical mirror (35 x 35 centimeters) for the mirror exercises. The involved hand was positioned behind the mirror and the non-involved hand facing mirror. The practice consisted of practicing the above exercise in the same progression according to each phase of

treatment, three times per week for four weeks, with the non-involved as the patient watched the mirror image of their hand, the projected reflection of their hand movement was shown directly over the affected hand. When looking in the mirror, patients could only see their non-involved hand, as the involved hand was hidden. At certain points throughout the session, patients were instructed to mimic their motions with the uninvolved hand using the involved hand. Whereas the "control" group did the same exercise for the same amount of time, but with the mirror turned so that the involved hand was hidden from view. All the patients received mirror or sham treatment from the same therapist (Yavuzeret al., 2008).

The outcomes measured included total active range of motion of interphalangeal joints of the involved finger, hand grip strength, and hand function:

- Total active range of motion of IP joints of every affected digit was measured three times utilizing finger goniometer (Baseline 12-1011 Finger Goniometer, Metal, 180 Degree - 6" Deluxe) at the fourth, the sixth, and the eight-week post-operative (Bain et al., 2014).
- Hand grip strength of both hands for every patient was evaluated once utilizing hand dynamometer at the 12^{th} week post-operative (Takei Analog Hand Grip Strength Dynamometer T.k.k.5001 GRIP-A General Type). A comparison of operated hand grip strength to unaffected hand grip strength was determined as a percentage. Because the dominant hand is typically stronger by a factor of 10, 10% was subtracted from the value of the operated hand's strength prior to the total was calculated (Trosclair et al., 2011).
- Hand function was assessed also for only one time after 12^{th} week post-operative by using the Arabic version of Michigan hand outcomes questionnaire that can assess the patient's dominant health state, which is relevant to the diagnosis of a hand disorder. Each patient was asked to answer the questions of its 6 scales (1- Generally hand function, 2-DailyActivities, 3-Work performance, 4- Pain, 5- Aesthetics, as well as 6-Hand function Satisfaction). The score for each scale ranged discretely from 0 to 100. Using the MHQ scoring system, we established the raw scale score to a range from 0 to 100 (Khaja et al., 2020).

2.3. Data Analysis

To compare age between groups, descriptive statistics and unpaired t-test were conducted. Chi-squared test was conducted for comparison of sex, dominant, and involved hand distribution, as well as operated finger distribution. For comparison of total AROM, hand grip, and function among groups, an unpaired t-test was conducted. Paired t-test was carried out for comparison among pre-

and post-treatment mean values of total active ROM, hand grip, and hand function in each group. The significance level was set at $p < 0.05$ for all statistical tests. The 25th edition of IBM's statistical software for the social sciences (SPSS; Chicago, Illinois, USA) was used for all analyses.

3. RESULTS

Figure 1 shows the flow diagram of patient allocation at each stage of the study.

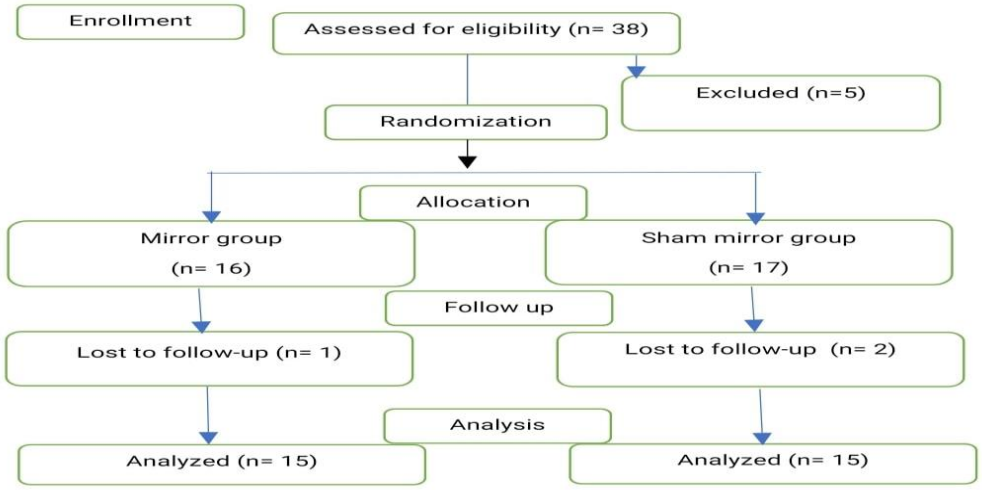

Figure 1. Flow diagram of patient allocation at each stage of the study

Tables 1 and 2 list the general and medical characteristics of the two groups. Table 1 indicates that there was no statistically significant difference in mean age or sex between the groups ($p>0.05$)

Table 1. Demographic data

Variables	Mirror therapy group	Sham mirror therapy group	P value
	$\bar{X} \pm$ SD	$\bar{X} \pm$ SD	
Age (years)	36.4 ± 6.27	35.13 ± 6.42	0.58
Sex (male or female)	Female 4(26.66%)	Female 6(40%)	0.48
	Male 11(73.33%)	Male 9(60%)	

X: Mean; SD: Standard deviation; p value: Probability value

Table 2 presents the frequency distribution and Fisher's Exact test for dominant hand, involved hand, and involved finger distribution, all of which revealed no significant differences ($p> 0.05$).

Table 2. Dominant and injured hand and operated finger distribution

Variables	Mirror therapy group	Sham mirror therapy group	χ2	P- value
Injured hand	Dominant hand 10(66.66%)	Dominant hand 12 (80%)	2.08	0.21
	Non dominant hand 5(33.33.%)	Non dominant hand 3(20%)		
Operated finger	Index3(20%)	Index5(30%)		
	Middle6(36.7%)	Middle3(20%)		
	Ring4(30%)	Ring3(23.3%)		
	Little2(13.3%)	Little4(26.7%)	3.58	0.32

χ2: Chi Squared Value; p value: probability value

3.1. Within group comparison

There is a statistically significant improvement in IP joints AROM of operated fingers at 6th, as well as 8th post-operative weeks compared to that of 4thpostoperative week (p = 0.001), a substantial increase in IP joints AROM of operated fingers at 8th postoperative week in comparison with that at 6th postoperative week in both groups (p = 0.001) (Table 3).

Table 3. Mean values of IP joints AROM of operated digits between both groups

Total active ROM	Mirror therapy group		Sham mirror therapy group		MD (95% CI)	t value	P value
	$\overline{X}$ ± SD		$\overline{X}$ ± SD				
4th week	93.66±10.09		98.8±13.17		-13.908	-1.198	.058
6th week	106.13±11.51		106.53±13.07		-9.612	-.089	.411
8th week	119.4±9.34		118.73±11.27		-7.081	.176	.377
	F =23.161 P = 0.000		F = 9.639 P= 0.000				
Multiple comparison (Bonferroni test)	**Mirror therapy group**			**Sham mirror therapy group**			
	MD	**% of change**	**p- value**	**MD**	**% of change**		**p- value**
4-6 week	19.5	12.5	.000*	16.06	7.73		.000*
4-8 week	-0.4	-25.7	.003*	-2.23	-19.93		.033*
6-8 week	-19.1	-13.2	.006*	-13.8	-12.2		.000*

**. The mean difference is significant at the 0.05 level.*

3.2. Between group comparison

There was a substantial increase in IP joints AROM of operated fingers at 6th, and 8thpost-operative weeks of or therapy group in comparison with that of sham mirror therapy (p < 0.05) (Table 4). Also, there was a potential increase in operated hand grip strength (% of normal hand) of mirror therapy in comparison with that of sham mirror therapy at 12th postoperative week and a significant increase in scores of overall hand function, activities of daily living, work, aesthetics,

satisfaction, as well as a significant decrease in score of pain of mirror therapy compared with that of sham mirror therapy at 12th post-operative week ($p < 0.05$) (Table 4).

Table 4. Mean operated hand grip strength (% of normal hand) and MHQ scales scores at 12th postoperative week in both groups

Variables	Mirror therapy group	Sham-mirror therapy group	MD (95% CI)	t-value	p-value
	Mean ±SD	Mean ±SD			
Grip strength (% of normal hand)	75.7±5.38	69.33±5.65	6.37(3.51:9.21)	4.46	0.001
MHQ					
1- Overall hand function	49.58±33.12	40.17±20.99	13.5(5.71:21.29)	3.46	0.001
2- Activities of daily living	40.62±22.54	38.79±26.48	6.56(0.92:12.2)	2.33	0.02
3- Work	54.58±25.97	38.33±24.34	8.67(4.26:13.06)	3.94	0.001
4- Pain	34.58±16.02	42.50±24.44	-6.83(-10.49: 3.16)	-3.73	0.001
5- Aesthetics	46.9±17.14	34.9±21.06	6.86(2.02:11.71)	2.83	0.006
6- Satisfaction	50.31±32.05	49.27±29.18	6.93(2.08:11.78)	2.86	0.006

4. DISCUSSION

The current study demonstrated a statistical significant improvement in the overall active ROM of IP joints of the involved finger, hand grip and hand function in the two groups. The mirror therapy group had greater significant improvement in all the outcome measures when in comparison with the sham mirror therapy group ($p<0.05$).

The main goals of any FTR are to enhance intrinsic tendon healing and limit the development of peritendinous adhesions aiming to restore maximum tendon excursion and ROM. In spite of unlimited evolution in materials, techniques, and approaches utilized in either surgical repair or post-repair rehabilitation of flexor tendons, complications continue to develop postoperatively, even in patients managed by highly experienced hand surgeons and therapists. Postoperative formation of peritendinous adhesions is nevertheless the most happening complication that significantly limits the AROM of the operated digits which certainly affects hand strength and functions (Tang et al., 2022; Klifto et al, 2018). The postoperative physical therapy significantly affects the outcomes of a good quality FTR. Up to now, there is no agreement on a single physiotherapy protocol to be optimal (Ayhan et al., 2021).

Up to the authors' knowledge, however, no study has investigated the effect of adding the mirror therapy to the physical therapy exercises post flexor tendon repair. Instead, most previous studies have looked at different types of splints or different hand exercises programs that were done in the traditional way. The findings of our study are similar to those of another studies, which

reported that MT has a positive impact on improving the ROM, hand grip, and hand function (Karnati et al., 2015; Shaker et al., 2020). Also, the improvement in the sham mirror therapy group came in agreement of many studies (Zarraa et al., 2022; Neiduski & Powell, 2019; Sanmartín-Fernández et al., 2017). According to our study, adding mirror therapy is beneficial in improving the total active IP ROM, hand grip, and hand function.

This superior effect in the mirror therapy group can be attributed to the bimodal visuo-motor nature of the motor neurons that became active throughout movement observation, mental stimulation through imaging, and/or movement execution. So, the illusion created by the non-operated increased the excitation of the primary motor cortex of the hand behind the mirror (operated hand) that created a substitution for the inhibited proprioceptive information from the operated hand. This intersected facilitatory input from the active hemisphere of the non-operated hand will lead to increase the excitability in the homologues motor pathways of the operated hand and felicitating its recovery. Also, the mirror created visual feedback of successfully performed performance of the imagined activity with the operated hand that had a beneficial effect in the rehabilitation. So, this connection between the pre-motor area activation in addition to the visual input assists the rehabilitation in a good way and enhanced the patients' recovery (Arya et al., 2016; Rizzolatti & Craighero, 2004; Thill et al., 2016).

5. LIMITATIONS

The research has some limitations. First, the relatively small sample size of the study group, which means that a larger sample is essential for more robust statistical analysis. Second, there was a lack of follow-up for both groups to evaluate the long-term effects of mirror therapy (MT) on improving hand function in futsal referees (FTR). Consequently, more studies are needed to address these limitations.

6. CONCLUSIONS

Adding MT to the traditional PT program might be more effective than the traditional PT program alone concerning IP joints AROM of the operated fingers, grip strength, as well as MHQ scales. Our study results suggest that therapists and health professionals should think about adding MT to the conventional postoperative rehabilitation for patients who underwent FTR.

7. REFERENCES

1. Arya, K. N. (2016). Underlying neural mechanisms of mirror therapy: Implications for motor rehabilitation in stroke. *Neurology India, 64*(1), 38-44. https://doi.org/10.4103/0028-3886.173622
2. Ayhan, E., Tuna, Z., & Oksuz, C. (2021). Getting better results in flexor tendon surgery and therapy. *Plastic and Reconstructive Surgery- Global Open, 9*(2), 1-6.
3. Bain, G. I., Polites, N., Higgs, B. G., Heptinstall, R. J. & McGrath. A. M. (2014). The functional range of motion of the finger joints. *Journal of Hand Surgery, 40*(4), 406-411.
4. Dy, C. J., Hernandez-Soria, A., Ma, Y., Roberts, T. R., & Daluiski, A. (2012). Complications after flexor tendon repair: a systematic review and meta-analysis. *Journal of Hand Surgery, 37*(3), 543–551. https://doi.org/10.1016/j.jhsa.2011.11.006
5. Henry, S. L., & Howell, J. W. (2020). Use of a relative motion flexion orthosis for postoperative management of zone I/II flexor digitorum profundus repair: A retrospective consecutive case series. *Journal of Hand Therapy, 33*(3), 296–304. https://doi.org/10.1016/j.jht.2019.05.002
6. Kang, Y. J., Ku, J., Kim, H. J., & Park, H. K. (2011). Facilitation of corticospinal excitability according to motor imagery and mirror therapy in healthy subjects and stroke patients. *Annals of Rehabilitation Medicine, 35*(6), 747–758. https://doi.org/10.5535/arm.2011.35.6.747
7. Karnati, V. P., Maddirala, R., & Mohammed, A. M. A. (2015). Effectiveness of mirror therapy on hand functions in subacute stroke patients. *International Journal of Physiotherapy, 2*(4), 646-651.
8. Khaja, A., Alroudhan, M., Hanna, S., Boshahri, M., AlAwad, M. & Alsamhan, A. (2020). Cross-cultural adaptation, validation and reliability of the Michigan hand outcomes questionnaire: The Arabic-version. *BMC Musculoskeletal Disorders, 4*(1), 1-6.
9. Klifto, C. S., Capo, J. T., Sapienza, A., Yang, S. S., & Paksima, N. (2018). Flexor Tendon Injuries. *The Journal of the American Academy of Orthopaedic Surgeons*, *26*(2), 26–35. https://doi.org/10.5435/JAAOS-D-16-00316
10. Lilly, S. I., & Messer, T. M. (2006). Complications after treatment of flexor tendon injuries. *The Journal of the American Academy of Orthopaedic Surgeons*, *14*(7), 387–396. https://doi.org/10.5435/00124635-200607000-00001
11. Matthys, K., Smits, M., Geest, J. N., Van der Lugt, A., Seurinck, R., Stam H. J. & Selles, R. W. (2009). Mirror induced visual illusion of hand movements: A functional magnetic resonance imaging study. *Archives of Physical Medicine and Rehabilitation, 90*(4), 675-681.
12. Neiduski, R. L., & Powell, R. K. (2019). Flexor tendon rehabilitation in the 21st century: A systematic review. *Journal of Hand Therapy, 32*(2), 165-174.

13. Neumann, D. A. (2013). *Kinesiology of the kinesiology of the musculoskeletal system: Foundations for rehabilitation.* Elsevier Health Sciences.
14. Newington, L., Ross, R., & Howell, J. W. (2021). Relative motion flexion splinting for the rehabilitation of flexor tendon repairs: A systematic review. *Hand Therapy*, *26*(3), 102–112. https://doi.org/10.1177/17589983211017584
15. Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. *Annual Review of Neuroscience*, *27*, 169–192. https://doi.org/10.1146/annurev.neuro.27.070203.144230
16. Rrecaj, S., Martinaj, M., Murtezani, A., Ibrahimi-Kaçuri, D., Haxhiu, B., & Zatriqi, V. (2014). Physical therapy and splinting after flexor tendon repair in zone II. *Medical Archives (Sarajevo, Bosnia and Herzegovina)*, *68*(2), 128–131. https://doi.org/10.5455/medarh.2014.68.128-131
17. Sanmartín-Fernández, M., Fernández-Bran, B., & Couceiro-Otero, J. (2017). Home-based rehabilitation in the postoperative treatment of flexor tendon repair. Rehabilitación domiciliaria en el tratamiento postoperatorio de la reparación de los tendones flexores. *Revista Espanola de Cirugia Ortopedica y Traumatologia*, *61*(4), 224–232. https://doi.org/10.1016/j.recot.2017.02.006
18. Savage, R., Pritchard, M. G., Thomas, M., & Newcombe, R. G. (2005). Differential splintage for flexor tendon rehabilitation: an experimental study of its effect on finger flexion strength. *Journal of Hand Surgery*, *30*(2), 168–174. https://doi.org/10.1016/j.jhsb.2004.10.014
19. Shaker, H., Fahmy, E., Anwar, E., Honin, N. & Shaheen, S. (2020). Effect of mirror therapy on hand functions in Egyptian chronic stroke patients. *The Egyptian Journal of Neurology Psychiatry and Neurosurgery*, *56*(1), 1-6.
20. Tang, J. B., Lalonde, D., Harhaus, L., Sadek, A. F., Moriya, K., & Pan, Z. J. (2022). Flexor tendon repair: recent changes and current methods. *The Journal of Hand Surgery*, *47*(1), 31–39. https://doi.org/10.1177/17531934211053757
21. Thieme, H., Morkisch, N., Rietz, C., Dohle, C., & Borgetto, B. (2016). The Efficacy of Movement Representation Techniques for Treatment of Limb Pain--A Systematic Review and Meta-Analysis. *The Journal of Pain*, *17*(2), 167–180. https://doi.org/10.1016/j.jpain.2015.10.015
22. Thill, S., Caligiore, D., Borghi, A. M., Ziemke, T., & Baldassarre, G. (2013). Theories and computational models of affordance and mirror systems: an integrative review. *Neuroscience and Biobehavioral Reviews*, *37*(3), 491–521. https://doi.org/10.1016/j.neubiorev.2013.01.012
23. Trosclair, D. Bellar, D., Judge, L. W., Smith, J., Mazerat, N. & Brignac, A. (2011). Hand-grip strength as a predictor of muscular strength and endurance. *Journal of Strength and Conditioning Research, 25,* 89-99.

24. Yavuzer, M., Selles, R., Sezer, N., Tomruk S. S., Bussmann, J., Köseoğlu, F., Atay, M. & Stam, H. (2008). Mirror therapy improves hand function in subacute stroke: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation, 89*(3), 393-398.
25. Zarraa, A., Ahmed, E., Khalil, A. & Abd El Baky, A. (2022). Relative motion protocol versus place and hold protocol after hand zone ii flexor tendon repair: A Prospective randomized controlled trial. *The Egyptian Journal of Hospital Medicine, 89*(2), 6617-6621.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

COPYRIGHT