RESEARCH PAPER

Effectiveness of Closed Kinetic Chain Exercises on Quality of Hand Function in Patients with Rheumatoid Arthritis

Ms. Arya Sandip Deshmukh[1*], Dr. Poonam Patil[2]

[1*]Student Intern Krishna College Of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad

[2]Associate Professor Department Of Cardiopulmonary Sciences Krishna College Of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad

ABSTRACT

Background: Rheumatoid arthritis (RA) is a chronic autoimmune inflammatory disorder that commonly affects the small joints of the hands and wrists, resulting in pain, reduced grip strength, impaired dexterity, and functional disability. Although exercise therapy is widely recommended in the rehabilitation of RA, limited evidence exists regarding the effectiveness of progressive closed kinetic chain (CKC) exercises for improving hand function in individuals with rheumatoid arthritis.

Objective: To evaluate the effectiveness of a progressive closed kinetic chain exercise program on pain intensity, grip strength, and hand function in patients with rheumatoid arthritis.

Methods: An experimental pre-test and post-test study design was conducted among 25 participants clinically diagnosed with rheumatoid arthritis presenting with hand and wrist involvement. Participants underwent a supervised 6-week progressive CKC exercise program performed three sessions per week. Outcome measures included the Numeric Pain Rating Scale (NPRS) for pain intensity, Jamar hand dynamometer for grip strength assessment, and Patient-Rated Wrist/Hand Evaluation (PRWHE) questionnaire for functional hand assessment. Pre- and post-intervention data were analysed using paired t-test with statistical significance set at $p < 0.05$.

Results: Following the 6-week intervention, statistically significant improvement was observed in all outcome measures. Mean NPRS scores decreased from 6.84 ± 1.02 to 3.92 ± 0.96 ($p < 0.001$). Grip strength improved significantly from 14.28 ± 3.11 kg to 18.96 ± 3.42 kg ($p < 0.001$). PRWHE scores also demonstrated significant reduction from 58.44 ± 7.65 to 39.16 ± 6.88 ($p < 0.001$), indicating improvement in hand and wrist function.

Conclusion: The present study demonstrated that a progressive closed kinetic chain exercise program significantly improved pain intensity, grip strength, and hand function in patients with rheumatoid arthritis. The findings suggest that CKC exercises may serve as a safe and effective rehabilitation approach for enhancing upper extremity function and functional independence in individuals with rheumatoid arthritis-related hand dysfunction.

Keywords: Rheumatoid arthritis; Closed kinetic chain exercise; Hand function; Grip strength; Physiotherapy rehabilitation; PRWHE

How to cite this article*:* Deshmukh AS, Patil P. Effectiveness of Closed Kinetic Chain Exercises on Quality of Hand Function in Patients with Rheumatoid Arthritis. Int J Drug Deliv Technol. 2026;16(59s): 1225-1232. DOI: 10.25258/ijddt.16.59s.138

Source of support: Nil.

Conflict of interest: Nil.

INTRODUCTION

Rheumatoid arthritis (RA) is a chronic, systemic autoimmune inflammatory disorder characterized by persistent synovial inflammation, progressive cartilage destruction, joint deformity, and functional disability.[1,2] It affects approximately 0.5–1% of the global population and occurs more commonly in women than men, with peak onset between 30 and 60 years of age.[2,3] The disease predominantly involves the small joints of the hands and wrists, resulting in pain, swelling, stiffness, muscle weakness, reduced grip strength, and impaired dexterity that significantly limit activities of daily living (ADLs) and occupational performance.[1,3] Hand dysfunction is considered one of the earliest and most disabling manifestations of RA, contributing substantially to long-term disability and reduction in quality of life.[4]

Previous epidemiological studies have reported that nearly 94% of patients with rheumatoid arthritis experience hand symptoms, while approximately 88% demonstrate activity limitations related to impaired hand function.[1] Persistent synovitis and joint instability lead to deterioration in fine motor control, compromised proprioception, and reduced functional independence.[2,5] Consequently, restoration and preservation of hand function remain central goals in the multidisciplinary rehabilitation of patients with RA.[6]

Pharmacological management, including disease-modifying antirheumatic drugs (DMARDs) and biologic

**Author for Correspondence:*

agents, has significantly improved disease control and reduced inflammatory activity.[3] However, despite advances in medical management, many patients continue to experience residual pain, weakness, stiffness, and functional limitations of the upper extremity.[7] Therefore, physiotherapy interventions play a crucial role in maintaining joint mobility, improving muscle performance, enhancing physical function, and minimizing disability.[4,6]

Exercise therapy has been widely recommended as a safe and effective non-pharmacological intervention for patients with inflammatory arthritis.[8,12]

Several systematic reviews and randomized controlled trials have demonstrated that structured hand exercise programs can improve grip strength, reduce pain, and enhance hand function without exacerbating disease activity in individuals with RA.[5,7–10] Conventional rehabilitation programs primarily include range of motion exercises, stretching, isometric strengthening, joint protection strategies, splinting, and functional training.[6,8] Most of these interventions are based on open kinetic chain (OKC) exercises, which typically isolate individual muscle groups and may provide limited functional carryover to complex daily tasks requiring coordinated multi-joint stabilization.[14]

Closed kinetic chain (CKC) exercises represent an alternative rehabilitation approach in which the distal segment remains fixed while multiple joints move simultaneously under compressive loading conditions.[14] CKC exercises promote co-contraction of agonist and antagonist muscles, enhance proprioceptive feedback, improve neuromuscular control, and increase dynamic joint stability.[13,14] In orthopaedic and sports rehabilitation, CKC exercises have shown superior outcomes in enhancing joint stabilization, muscle activation, and functional performance compared to isolated strengthening exercises.[15] Functional weight-bearing CKC tasks also mimic real-life upper extremity activities such as pushing, gripping, weight transfer, and object manipulation, thereby potentially improving ADL performance and sensorimotor integration.[17]

Recent evidence has further highlighted the effectiveness of supervised and task-specific hand exercise programs in improving upper limb function among patients with rheumatoid arthritis.[9,18] Dynamic stabilization exercises targeting the thumb and wrist have also demonstrated improvements in grip strength, joint stability, and functional outcomes.[16] Moreover, EULAR recommendations strongly advocate regular physical activity and individualized exercise therapy as essential components in the management of inflammatory arthritis.[12]

Despite the growing evidence supporting exercise-based rehabilitation in RA, there remains limited literature specifically investigating the role of CKC exercises in improving hand and wrist function in patients with rheumatoid arthritis.[13,14] Most available studies have focused on general strengthening or mobility exercises, while the potential benefits of progressive CKC training on pain modulation, grip strength, proprioception, and functional hand performance remain underexplored.[5,7] Furthermore, there is a scarcity of studies evaluating structured CKC protocols specifically designed for hand rehabilitation in RA populations.[14]

Therefore, the present study aims to evaluate the effectiveness of a progressive closed kinetic chain exercise program on pain intensity, grip strength, and hand function in patients with rheumatoid arthritis. The findings of this study may contribute to the development of evidence-based physiotherapy protocols emphasizing functional stabilization and task-oriented rehabilitation for improving upper extremity performance and quality of life in individuals with RA.

MATERIALS AND METHODS

Study Design

The present study was conducted using an experimental pre-test and post-test study design to evaluate the effectiveness of a progressive closed kinetic chain exercise program on pain intensity, grip strength, and hand function in patients with rheumatoid arthritis.

Study Setting

The study was conducted in the Department of Physiotherapy, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad, Maharashtra, India.

Study Population

Patients clinically diagnosed with rheumatoid arthritis presenting with hand and wrist involvement were recruited for the study.

Sampling Technique

A purposive sampling technique was used to recruit participants who fulfilled the inclusion and exclusion criteria. Based on the calculation, the estimated sample size was 22 participants. Considering feasibility and possible dropouts, a total of 25 participants were recruited for the study.

Inclusion Criteria

Inclusion in the study will include patients clinically diagnosed with rheumatoid arthritis who are aged 30 to 60 years old. Both males and females suffering from rheumatoid arthritis can take part in this study. Participants must exhibit mild to moderate involvement in the joints of their hands and wrists caused by rheumatoid arthritis. Such criteria will ensure that there will be a proper sample chosen for the study that suffers from rheumatoid arthritis.

Exclusion Criteria

The study will not involve individuals who suffer from major hand and wrist deformities, since this may have a significant impact on the analysis and outcome. Also, participants who recently suffered from fractures or have undergone any surgical procedure related to the upper limb will be omitted from the research sample, in order to prevent the presence of any after-surgery or injury effects on the results of the analysis. Patients who have any neurological disorder affecting their upper limbs will not participate in the experiment either, because such issues will have an impact on the measurement of hand and wrist activity.

Ethical Approval and Participant Consent

The Ethical Approval for undertaking the proposed study has been obtained from the Institutional Ethics Committee of Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, with their Letter No. KVV/IEC/02/2026 dated 21st January 2026. Written informed consent was obtained from all the participants, who were assured of confidentiality and their right to withdraw anytime.

Outcome Measures

Numeric Pain Rating Scale (NPRS)

Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), a valid and reliable self-reported outcome measure consisting of an 11-point scale ranging from 0 to 10, where 0 represents "no pain" and 10 represents "worst imaginable pain."

Hand Grip Strength

Grip strength was assessed using a Jamar hand dynamometer. Participants were instructed to perform maximal voluntary grip contraction in a standardized sitting position with the shoulder adducted, elbow flexed to 90°, forearm in neutral position, and wrist slightly extended. Three readings were recorded, and the average value was considered for analysis.

Patient-Rated Wrist/Hand Evaluation (PRWHE)

Hand and wrist function were assessed using the Patient-Rated Wrist/Hand Evaluation (PRWHE) questionnaire. The PRWHE consists of pain and functional disability subscales used to evaluate upper extremity functional performance. Higher scores indicate greater pain and disability.

Procedure

Participants fulfilling the inclusion criteria were informed about the study protocol, and written informed consent was obtained prior to participation. Baseline assessments including pain intensity, grip strength, and hand function were recorded before initiation of the intervention.

All participants underwent a progressive closed kinetic chain exercise program for a duration of 6 weeks, with three sessions per week. Each session was conducted under the supervision of a physiotherapist. The intervention protocol included progressive functional weight-bearing exercises focusing on joint stabilization, proprioception, neuromuscular control, and functional hand activities.

At the completion of the 6-week intervention period, post-treatment assessments were conducted using the same outcome measures.

INTERVENTIONAL PROTOCOL

Table 1. INTERVENTIONAL PROTOCOL

Week	Goal	Exercises	Dosage	Functional Activity	Clinical Rationale
Week 1	Gentle CKC activation and proprioception	Wrist circles, finger flexion-extension, soft ball squeeze, seated table press, wall fingertip presses, palm compression on cushion, finger pad press, supported wrist compression	Seated table press: 10 sec × 3 reps Wall fingertip presses: 10 reps Palm compression: 3 × 10 reps Finger pad press: 10 reps Supported wrist compression: 10 reps	Pick up cup and place on shelf × 5 repetitions	Low-load static CKC exercises promote early co-contraction, proprioceptive stimulation, pain reduction, and joint stabilization.
Week 2	Dynamic CKC activation and coordination	Finger stretching, ball squeeze, table slides, palm press and release, inclined wall pushes, CKC finger curl variation, ball press exercises	Table slides: 10 reps Palm press and release: 3 × 10 reps Inclined wall pushes: 3 × 8 reps Finger curl CKC: 10 reps Ball press: 5 sec hold × 10 reps	Slide object on table × 5 repetitions	Dynamic CKC loading improves neuromuscular coordination, load tolerance, and sensorimotor control.

Week 3	Moderate CKC loading and wrist stability	Wrist rotations, ball squeeze, finger walking, wall push-ups, ball press on wall, fingertip push, palm weight-shift, kneeling forearm plank	Wall push-ups: 3 × 8 reps Ball press on wall: 10 reps Fingertip push: 3 × 10 reps Palm weight-shift: 10 reps Forearm plank: 10 sec × 3 reps	Open and close drawer × 5 repetitions	Progressive CKC loading enhances dynamic wrist stabilization, muscular activation, and compressive joint stability.
Week 4	Dynamic CKC progression and thumb control	Wrist circles, finger spreading, inclined push exercises, thumb press, ball roll under palm, wrist weight-shift, table plank	Inclined push: 3 × 8 reps Thumb press: 10 reps Ball roll under palm: 10 reps Wrist weight-shift: 3 × 10 reps Table plank: 15 sec × 3 reps	Carry light tray × 3 repetitions	CKC thumb and wrist loading improves carpometacarpal stabilization, proprioception, and upper limb load-bearing control.
Week 5	Task-specific CKC and fine motor control	Finger tapping, stretching, weight-shift CKC exercises, fingertip loading, palm-to-fist CKC, soft ball push, dynamic thumb loading	Weight-shift CKC: 3 × 10 reps Fingertip loading: 3 × 10 reps Palm-to-fist CKC: 3 × 10 reps Soft ball push: 5 sec × 10 reps Dynamic thumb loading: 3 × 8 reps	Pick and transfer object circuit × 3 rounds	Task-specific CKC activities enhance fine motor coordination, proprioceptive feedback, and functional hand performance.
Week 6	Functional integration and endurance	Stretching, ball squeeze, kneeling push-ups, CKC circuit training, isometric wrist extension, inclined plank, dynamic thumb stabilization	Kneeling push-ups: 3 × 8–10 reps CKC circuit: 2 rounds Isometric wrist extension: 10 sec × 3 reps Inclined plank: 20 sec × 3 reps Dynamic thumb stabilization: 3 × 8 reps	Simulated kitchen and ADL tasks × 3 rounds	Advanced CKC integration improves upper extremity endurance, functional strength, ADL performance, and neuromuscular efficiency.

RESULT

A total of 25 participants clinically diagnosed with rheumatoid arthritis completed the 6-week progressive closed kinetic chain exercise program. All participants successfully completed the intervention protocol and post-intervention assessment. No major adverse events or exercise-related complications were reported during the study period.

Baseline and post-intervention assessments were conducted using the Numeric Pain Rating Scale (NPRS), hand grip dynamometer, and Patient-Rated Wrist/Hand Evaluation (PRWHE) questionnaire to evaluate pain intensity, grip strength, and functional hand performance, respectively.

Demographic Characteristics

The demographic and clinical characteristics of the participants are presented in Table 1. The mean age of the participants was 46.32 ± 7.18 years. Female participants constituted the majority of the study population. The average disease duration was 5.21 ± 2.43 years.

Table 2. Demographic Characteristics of Participants (N = 25)

Variable	Mean ± SD / Frequency (%)
Age (years)	46.32 ± 7.18

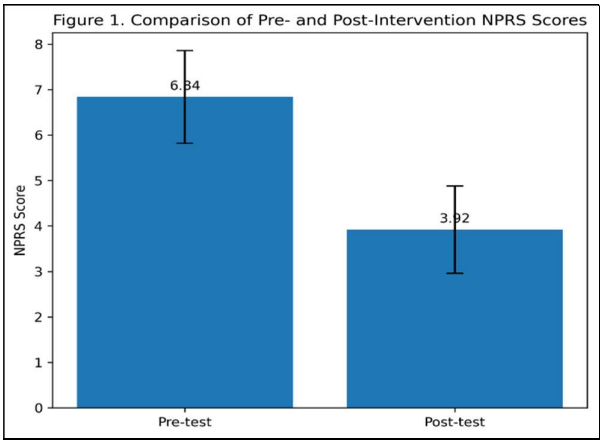
Female	18 (72%)
Male	7 (28%)
Disease Duration (years)	5.21 ± 2.43
Dominant Hand Involvement	16 (64%)
Bilateral Hand Involvement	11 (44%)

Comparison of Pain Intensity Before and After Intervention

Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS). A statistically significant reduction in pain intensity was observed following completion of the 6-week closed kinetic chain exercise program. The mean NPRS score decreased from 6.84 ± 1.02 during the pre-intervention assessment to 3.92 ± 0.96 following intervention. Paired t-test analysis demonstrated statistically significant improvement ($t = 9.41$, $p < 0.001$).

Table 3. Comparison of Pre- and Post-Intervention NPRS Scores

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
NPRS	6.84 ± 1.02	3.92 ± 0.96	9.41	<0.001*

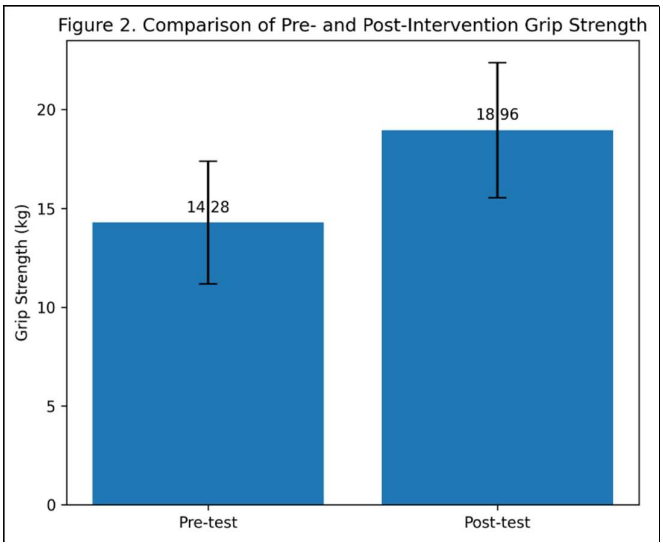


Comparison of Grip Strength Before and After Intervention

Grip strength measured using a hand dynamometer demonstrated significant improvement following the intervention protocol. The mean grip strength increased from 14.28 ± 3.11 kg at baseline to 18.96 ± 3.42 kg after completion of the intervention program. Statistical analysis revealed a significant difference between pre- and post-intervention values ($t = 7.83$, $p < 0.001$).

Table 4. Comparison of Pre- and Post-Intervention Grip Strength

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
Grip Strength (kg)	14.28 ± 3.11	18.96 ± 3.42	7.83	<0.001*

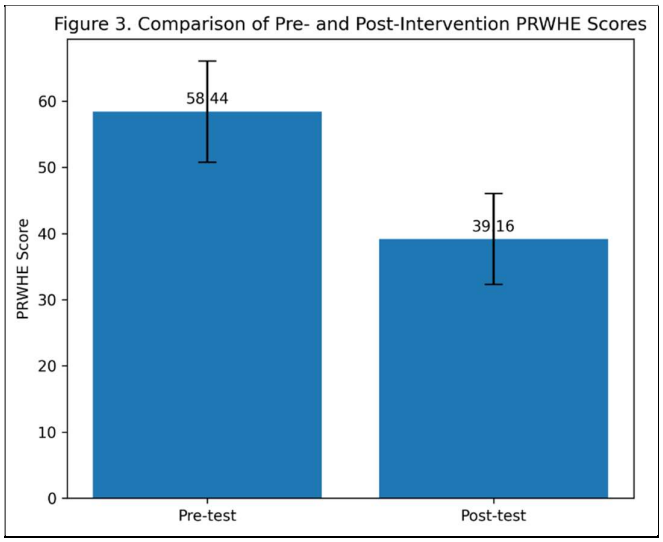


Comparison of Hand Function Before and After Intervention

Hand and wrist functional performance assessed using the Patient-Rated Wrist/Hand Evaluation (PRWHE) questionnaire showed statistically significant improvement after the intervention period. The mean PRWHE score decreased from 58.44 ± 7.65 at baseline to 39.16 ± 6.88 following intervention. Paired t-test analysis demonstrated statistically significant improvement in functional performance ($t = 10.27$, $p < 0.001$).

Table 5. Comparison of Pre- and Post-Intervention PRWHE Scores

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
PRWHE	58.44 ± 7.65	39.16 ± 6.88	10.27	<0.001*



The findings of the present study demonstrated statistically significant improvements in pain intensity, grip strength, and hand function following the 6-week progressive closed kinetic chain exercise program in patients with rheumatoid arthritis.

Participants exhibited clinically meaningful reduction in pain intensity, improvement in muscular performance, and enhancement in functional hand activities following the intervention protocol. The results suggest that progressive closed kinetic chain exercise training may be an effective rehabilitation approach for improving upper extremity function and functional independence in individuals with rheumatoid arthritis.

DISCUSSION

The present study evaluated the effectiveness of a progressive closed kinetic chain (CKC) exercise program on pain intensity, grip strength, and hand function in patients with rheumatoid arthritis. The findings

demonstrated statistically significant improvements in all outcome measures following the 6-week intervention protocol. Significant reduction in pain intensity along with improvement in grip strength and functional hand performance suggests that CKC exercises may be beneficial in the rehabilitation of hand dysfunction associated with rheumatoid arthritis.

Pain intensity assessed using the Numeric Pain Rating Scale (NPRS) showed significant reduction following the intervention. The reduction in pain may be attributed to improved joint stabilization, co-contraction of surrounding musculature, and enhanced proprioceptive feedback associated with CKC exercises.[13, 14] These findings are consistent with previous studies reporting beneficial effects of therapeutic exercise in reducing pain and improving physical function in individuals with rheumatoid arthritis.[4, 5]

Grip strength demonstrated statistically significant improvement after the intervention period. CKC exercises involve functional weight-bearing activities that facilitate coordinated activation of intrinsic and extrinsic hand musculature, thereby improving muscular performance and dynamic stabilization of the wrist and hand complex.[13, 14] Similar findings have been reported by Yoon and Kim, who demonstrated significant improvements in grip strength following CKC training.[13] Brorsson et al. also reported improvement in hand strength and upper extremity function following structured hand exercise programs in rheumatoid arthritis patients.[10]

The present study also demonstrated significant improvement in hand and wrist function assessed using the Patient-Rated Wrist/Hand Evaluation (PRWHE) questionnaire. The incorporation of task-specific and functional CKC activities such as gripping, pushing, and weight transfer may have contributed to improved upper extremity coordination and functional performance during activities of daily living. These findings are supported by Villafañe et al., who reported that functional upper extremity training significantly improves daily functional performance.[17]

The progressive nature of the intervention protocol may also have contributed to the positive outcomes observed in the present study. Gradual progression from low-load stabilization exercises to advanced functional and endurance-based CKC activities likely improved neuromuscular control, proprioception, and upper extremity stability without aggravating symptoms. No major adverse events were reported during the intervention period, indicating that CKC exercises are safe and clinically feasible for individuals with rheumatoid arthritis.

Despite the positive findings, the study had certain limitations including a relatively small sample size, absence of a control group, and lack of long-term follow-up. Further randomized controlled trials with larger sample sizes are recommended to establish the long-term effectiveness of CKC exercise programs in rheumatoid arthritis rehabilitation.

LIMITATIONS

The present study has certain limitations that should be considered while interpreting the findings. The study was conducted with a relatively small sample size and lacked a control group for comparison. The duration of intervention was limited to six weeks, and long-term follow-up was not performed to determine the sustainability of treatment outcomes. In addition, the study focused primarily on pain intensity, grip strength, and functional performance without assessing disease severity or psychosocial factors associated with rheumatoid arthritis. Further randomized controlled trials with larger sample sizes and long-term follow-up are recommended to establish stronger evidence regarding the effectiveness of closed kinetic chain exercise programs in rheumatoid arthritis rehabilitation.

Clinical Implications

The findings of the present study suggest that progressive closed kinetic chain exercises may serve as an effective rehabilitation approach for improving pain, grip strength, and hand function in patients with rheumatoid arthritis. Incorporation of task-specific CKC exercises into conventional physiotherapy rehabilitation programs may enhance upper extremity stability, proprioception, and functional independence during activities of daily living. The intervention protocol used in the present study may be clinically applicable in physiotherapy settings for individuals presenting with mild to moderate hand dysfunction associated with rheumatoid arthritis.

CONCLUSION

The present study demonstrated that a progressive closed kinetic chain exercise program significantly improved pain intensity, grip strength, and hand function in patients with rheumatoid arthritis. The intervention protocol effectively enhanced upper extremity stabilization, functional performance, and activities of daily living without producing adverse effects. The findings suggest that closed kinetic chain exercises may be considered a safe and effective physiotherapy rehabilitation strategy for individuals with rheumatoid arthritis-related hand dysfunction.

Acknowledgement

The authors would like to express sincere gratitude to the Department of Physiotherapy, Krishna College of Physiotherapy, Krishna Vishwa Vidyapeeth, Karad, for providing the facilities and support required for conducting the study. The authors also thank all participants for their valuable cooperation and participation throughout the study

REFERENCE

1. Hoeksma HL, van Zeben JJ, Roorda LD, Dekker J, Ronday HK, Stolk RP. Prevalence of hand symptoms, impairments and activity limitations in rheumatoid arthritis in relation to disease duration. J Rehabil Med. 2010;42(10):916-921. doi:10.2340/16501977-0619.
2. Scott DL, Wolfe F, Huizinga TWJ. Rheumatoid arthritis. Lancet. 2010;376(9746):1094-1108. doi:10.1016/S0140-6736(10)60826-4.
3. Smolen JS, Aletaha D, McInnes IB. Rheumatoid arthritis. Lancet. 2016;388(10055):2023-2038. doi:10.1016/S0140-6736(16)30173-8.
4. Baillet A, Zeboulon N, Gossec L, Combescure C,

Bodin LA, Juvin R, et al. Efficacy of exercise therapy in rheumatoid arthritis: a systematic review. Joint Bone Spine. 2012;79(2):111-117. doi:10.1016/j.jbspin.2011.02.005.

5. Hurkmans EJ, van der Giesen FJ, Vliet Vlieland TPM, Schoones J, van den Ende ECHM. Exercise therapy for hand function in rheumatoid arthritis patients: a systematic review. Cochrane Database Syst Rev. 2009;(4):CD003832. doi:10.1002/14651858.CD003832.pub2.
6. O'Brien AV, Jones P, Mullis R, Mulherin D, Dziedzic K. Conservative hand therapy treatments in rheumatoid arthritis: a systematic review. Rheumatology (Oxford). 2006;45(11):1398-1406. doi:10.1093/rheumatology/kel100.
7. Bergstra SA, Murgia A, Te Velde AF, Caljouw SR, van der Sluis CK, Dekker JH. A systematic review into the effectiveness of hand exercise therapy in the treatment of rheumatoid arthritis. Clin Rheumatol. 2014;33(11):1539-1548. doi:10.1007/s10067-014-2642-5.
8. Wessel J. The effectiveness of hand exercises for persons with rheumatoid arthritis: a systematic review. J Hand Ther. 2004;17(2):174-180. doi:10.1197/j.jht.2004.02.007.
9. Ellegaard K, Pedersen SG, Søgaard K, Danneskiold-Samsøe B, Bliddal H, Henriksen M. Supervised hand exercise therapy in women with rheumatoid arthritis improves hand function. Arthritis Res Ther. 2019;21(1):158. doi:10.1186/s13075-019-1937-0.
10. Brorsson S, Hilliges M, Sollerman C, Nilsdotter A, Bremander A. A six-week hand exercise programme improves strength and hand function in patients with rheumatoid arthritis. J Rehabil Med. 2009;41(5):338-342. doi:10.2340/16501977-0334.
11. Hu H, Xu A, Gao C, et al. The effect of physical exercise on rheumatoid arthritis: an overview of systematic reviews and meta-analysis. J Adv Nurs. 2021;77(2):506-522. doi:10.1111/jan.14619.
12. Rausch Osthoff AK, Niedermann K, Braun J, Adams J, Brodin N, Dagfinrud H, et al. EULAR recommendations for physical activity in people with inflammatory arthritis and osteoarthritis. Ann Rheum Dis. 2018;77(9):1251-1260. doi:10.1136/annrheumdis-2018-213585.
13. Yoon TL, Kim JH. Effects of closed kinetic chain exercise on hand function and grip strength in elderly women. J Phys Ther Sci. 2015;27(9):2777-2779. doi:10.1589/jpts.27.2777.
14. Karthikbabu S, Chakrapani M. Closed kinetic chain exercises: mechanisms and clinical applications. Int J Physiother Res. 2019;7(5):3224-3230. doi:10.16965/ijpr.2019.178.
15. Kim YS, Lee HM, Kim TH. Effects of push-up exercise at different palmar widths on upper extremity muscle activities. J Phys Ther Sci. 2016;28(3):967-970. doi:10.1589/jpts.28.967.
16. McVeigh KH, Bennell KL, Wajon A, et al. A dynamic stabilization home exercise program for thumb carpometacarpal conditions: a randomized pilot study. J Hand Ther. 2022;35(4):653-660. doi:10.1016/j.jht.2021.03.015.
17. Villafañe JH, Silva GB, Fernandez-Carnero J. Short-term effects of combined manual therapy and exercise therapy on upper limb function in patients with wrist disorders. J Orthop Sports Phys Ther. 2013;43(10):757-765. doi:10.2519/jospt.2013.4524.
18. Lamb SE, Williamson EM, Heine PJ, Adams J, Dosanjh S, Dritsaki M, et al. Exercises to improve function of the rheumatoid hand (SARAH): a randomised controlled trial. Lancet. 2015;385(9966):421-429. doi:10.1016/S0140-6736(14)60998-3.
19. Hammond A, Prior Y. The effectiveness of home hand exercise programmes in rheumatoid arthritis: a systematic review. Br Med Bull. 2016;119(1):49-62. doi:10.1093/bmb/ldw021.
20. Williamson E, Lamb SE, Heine PJ, Adams J, Dosanjh S, Dritsaki M, et al. Long-term follow-up and cost-effectiveness of the SARAH exercise programme for rheumatoid arthritis hands. Rheumatology (Oxford). 2017;56(1):65-75. doi:10.1093/rheumatology/kew289