Hand Surgery and Rehabilitation 38 (2019) 59–66

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

Original article

Effects of a finger exercise program on hand function in automobile workers with hand osteoarthritis: A randomized controlled trial

Effets d'un programme d'exercice digital sur la fonction de la main chez les travailleurs dans le secteur automobile présentant une rhizarthrose : un essai randomisé contrôlé

T.-W. Kang [a], J.-H. Lee [b], D.-H. Park [b], H.-S. Cynn [b,*]

[a] *Department of Physical Therapy, Wonkwang University School of Medicine & Hospital, Iksan, Jeollabuk-do, South Korea*
[b] *Applied Kinesiology and Ergonomic Technology Laboratory, Department of Physical Therapy, The Graduate School, Yonsei University, 220-710, Baekwoon-kwan, 1 Yonseidae-gil, Wonju, Kangwon-do, South Korea*

ARTICLE INFO

Article history:
Received 7 April 2018
Received in revised form 27 August 2018
Accepted 27 September 2018
Available online 3 November 2018

Keywords:
Hand
Osteoarthritis
Workers
Pain
Function
Strength

Mots clés :
Main
Arthrose
Travailleur
Douleur
Fonction
Force

ABSTRACT

Hand osteoarthritis reduces a person's ability to perform work activities and return to their occupation. We investigated the effects of a finger exercise program on hand grip strength, pain, physical function, and stiffness in automobile manufacturing workers with hand osteoarthritis. This randomized controlled trial was conducted on 29 subjects. Fifteen experimental subjects received a finger exercise program with paraffin baths, while 14 control subjects received only paraffin baths. Hand grip strength, pain, physical function, and stiffness were assessed at baseline and 8 weeks later. In the experimental group, hand grip strength ($P < 0.001$) and Australian/Canadian osteoarthritis hand index (AUSCAN) scores (pain, $P < 0.001$; stiffness, $P < 0.001$; physical function, $P < 0.001$) were significantly improved by 3.52 ± 2.03, 21.6 ± 8.3 (pain), 16.8 ± 10.21 (stiffness), and 13.86 ± 4.54 (physical function) compared with preintervention values. In the control group, hand grip strength ($P = 0.004$) and AUSCAN scores (pain, $P < 0.001$; stiffness, $P = 0.019$; physical function, $P < 0.001$) were significantly improved by 0.57 ± 0.62, 7.85 ± 5.46 (pain) 11.42 ± 7.18 (stiffness), and 10.28 ± 14.41 (physical function) compared with preintervention values. Significant differences between groups were found for postintervention hand grip strength ($P = 0.015$) and AUSCAN index subscale scores (pain, $P < 0.001$; physical function, $P = 0.020$). A combined finger exercise and paraffin bath program is effective in reducing pain, improving physical function, and increasing hand grip strength in workers with hand osteoarthritis.

RÉSUMÉ

L'arthrose de la main diminue les capacités à réaliser les tâches professionnelles et à reprendre une activité. Nous avons étudié les effets d'un programme d'exercice digital sur la force de prise de la main, la douleur, la fonction physique et la raideur chez des travailleurs de l'industrie automobile souffrant d'une arthrose de la main. Quinze sujets expérimentaux ont suivi un programme d'exercice digital accompagné de bains de paraffine, et 14 sujets contrôles n'ont bénéficié que de bains de paraffine. L'essai contrôlé randomisé a intéressé les 29 sujets. La force de prise de la main, la douleur, la fonction physique et la raideur ont été évaluées initialement et 8 semaines plus tard. Dans le groupe expérimental, la force de prise ($p < 0{,}001$) et les scores de l'index d'arthrose de la main australien et canadien (Australian/Canadian Osteoarthritis Hand Index AUSCAN) (douleur, $p < 0{,}001$; raideur,

* Corresponding author.
E-mail address: cynn@yonsei.ac.kr (H.-S. Cynn).

https://doi.org/10.1016/j.hansur.2018.09.007
2468-1229/

$p < 0{,}001$; fonction physique, $p < 0{,}001$) étaient significativement améliorés de 3,52 ± 2,03, 21,6 ± 8,3 (douleur), 16,8 ± 10,21 (raideur), et de 13,86 ± 4,54 (fonction physique) par rapport aux valeurs initiales. Dans le groupe témoin, la force de prise (p = 0,004) et les scores AUSCAN (douleur, $p < 0{,}001$; raideur, p = 0,019 ; fonction physique, $p < 0{,}001$) étaient significativement améliorés de 0,57 ± 0,62, 7,85 ± 5,46 (douleur) 11,42 ± 7,18 (raideur), et de 10,28 ± 14,41 (fonction physique) par rapport aux valeurs initiales. Des différences significatives dans les valeurs après traitement ont été observées pour la force de prise (p = 0,015) et certains scores de l'index AUSCAN (douleur, $p < 0{,}001$; fonction physique, p = 0,020). Un programme d'exercice digital combiné à des bains de paraffine et efficace dans la réduction de la douleur, améliore la fonction physique et augmente la force de prise en cas d'arthrose de la main.

1. Introduction

A recent report found the prevalence of hand osteoarthritis (HO) in the general population to be 15.9% among women and 8.2% among men [1]. Hand osteoarthritis is a common joint disorder that can cause severe pain and affect overall hand function [2]. Serious occupation-related hand injuries can lead to permanent dysfunction. HO and injuries can reduce the ability of individuals to perform daily activities and make it difficult for them to return to work [3,4]. HO is positively correlated with sex, age, metabolism, heredity, and biodynamic factors [5,6]. HO can limit activities and participation by causing pain in and around damaged joints and by reducing the range of motion (ROM) and grip strength [2,7]. The clinical symptoms of HO include soft tissue edema, osteophytes and bone erosion, and often appears in the distal interphalangeal (DIP) joints, the second through fifth proximal interphalangeal (PIP) joints, and the carpometacarpal joint of the thumb [8,9].

HO largely appears in workers who repeatedly use their hands or are involved in automobile manufacturing processes [10]. Among hand-related diseases, HO is of great importance due to its impact on hand function and job performance [8]. Pain and loss of hand function caused by HO decrease a person's ability to perform manual tasks and diminishes their quality of life. Patients with HO have reduced grip strength and complain of having more difficulty handling and manipulating small objects and writing [11]. Despite these problems, there is a notable lack of published clinical studies on the clinical impact, epidemiology, and treatment of HO.

The main interventions used to relieve the symptoms of osteoarthritis and prevent inactivity and functional losses include paraffin baths, exercise, manual therapy, hand therapy, and pharmacological treatments. International recommendations and guidelines for the treatment of osteoarthritis continue to be developed [10,12]. Because no treatments can completely cure HO, the goal is to relieve symptoms; thus, pharmacological treatments and non-pharmacological methods such as exercise, education and functional aids are used [13]. Although pharmacological treatments are recommended for HO [14], none of these have been shown to slow cartilage loss and thus should be regarded as symptom control. Therefore, non-pharmacological approaches are important [15]. Intermediate levels of physical activities are recommended to prevent the progression of HO by strengthening muscles [16]. Treatments recommended for patients with HO include joint protection, exercise programs using functional evaluations and aids, heat treatment, and use of auxiliary equipment [10,12].

Some studies have recommended rehabilitation exercises for patients with HO [8,9]. Our study was designed to address this need. Given that the musculoskeletal system must function as an integrated unit for optimal efficiency, specific exercise programs designed to improve hand function are an essential element of HO treatment. Increased fitness and muscle strength may help to stabilize bone and cartilage conditions [9]. Therefore, the purpose of this study was to apply an 8-week stretching and strengthening exercise program in automobile manufacturing workers with HO, and to examine its effects on hand grip strength and function. Our study findings may help improve the management of HO. Our hypothesis was that finger exercise combined with paraffin bath therapy (experimental group) would increase hand grip strength, reduce pain and stiffness, and improve physical function more than paraffin bath therapy alone (control group).

2. Patients and methods

2.1. Subjects

Pilot testing was performed on 6 volunteers, with 3 patients in the experimental group and 3 in the control group to determine the number of subjects required for this study. G*Power software (G*Power software 3.1.2; Franz Faul, University of Kiel, Kiel, Germany) set for the *t*-test was used to calculate the sample size for between group analyses of the primary outcome of the pilot study. A power analysis based on the results of the pilot study was completed to achieve a significant α level (0.05), power (0.80), and effect size (1.53). The results of the power analysis showed that the current study would require 5 participants in each group. Baseline characteristics between groups did not significantly differ, thus, yielding a small sample size and a high effect size. Thirty patients were recruited into our study from October 1, 2016 to October 20, 2016. Patients were male career workers recruited from an automobile assembly line. The patients were assigned to the experimental or control group using a random number generator with a block size of 10 and sealed envelopes. Allocation concealment was maintained by placing method indicator cards inside sequentially numbered, opaque, sealed envelopes. An epidemiologist who was not involved with the trial developed and performed this randomization scheme. The patient names and hospital numbers were written on the outside of the envelopes upon enrolment. The carbon paper inside the envelopes transferred this information to the method indicator cards, which were stapled to the data collection form to provide an audit trail.

Thirty subjects applied for the present study. Patients with HO were selected according to the inclusion criteria suggested by the American College of Rheumatology (ACR) [17]:

- hand pain or stiffness and hard tissue enlargement in at least 2 out of 10 selected joints;
- hard tissue enlargement of at least 2 DIP joints;
- 3 or fewer swollen metacarpophalangeal (MCP) joints;
- deformity in at least 1 out of 10 selected joints;
- at least 5 points in the functional index for hand osteoarthritis (FIHOA) [19].

The exclusion criteria were as follows:

Table 1
General characteristics.

Variable	Experimental group (n = 15) Mean ± SD	Control group (n = 14) Mean ± SD	t	P
Age (years)	46.7 ± 4.6	47.9 ± 4.0	−0.74	0.46
Career length (years)	19.4 ± 4.0	17.2 ± 3.6	1.55	0.13
Height (cm)	169.9 ± 5.5	169.4 ± 7.1	0.18	0.85
Mass (kg)	71.7 ± 7.6	72.7 ± 6.3	−0.40	0.69
BMI (kg/m^2)	24.8 ± 2.2	25.4 ± 2.0	−0.67	0.50
Symptom duration (years)	3.53 ± 0.9	3.5 ± 1.2	0.08	0.93
Number of painful hand joints	3.73 ± 0.9	3.86 ± 0.9	−0.36	0.85
Number of stiff hand joints	3.53 ± 0.9	3.50 ± 0.9	0.10	0.90
Number of bony knobs	2.33 ± 1.0	1.93 ± 0.9	1.10	0.28

BMI: body mass index; SD: standard deviation.

- presence of cognitive disorder;
- history of recent serious trauma;
- history of recent surgery for osteoarthritis or other major operations;
- having received a corticosteroid injection in a hand joint in the prior 2 months.

Table 1 summarizes the general characteristics of the subjects. While 30 subjects had applied for the present study and the trial was performed on an experimental group of 15 and a control group of 15, 1 person quit his job during the experiment; thus, the experimental group comprised 15 subjects and the control group

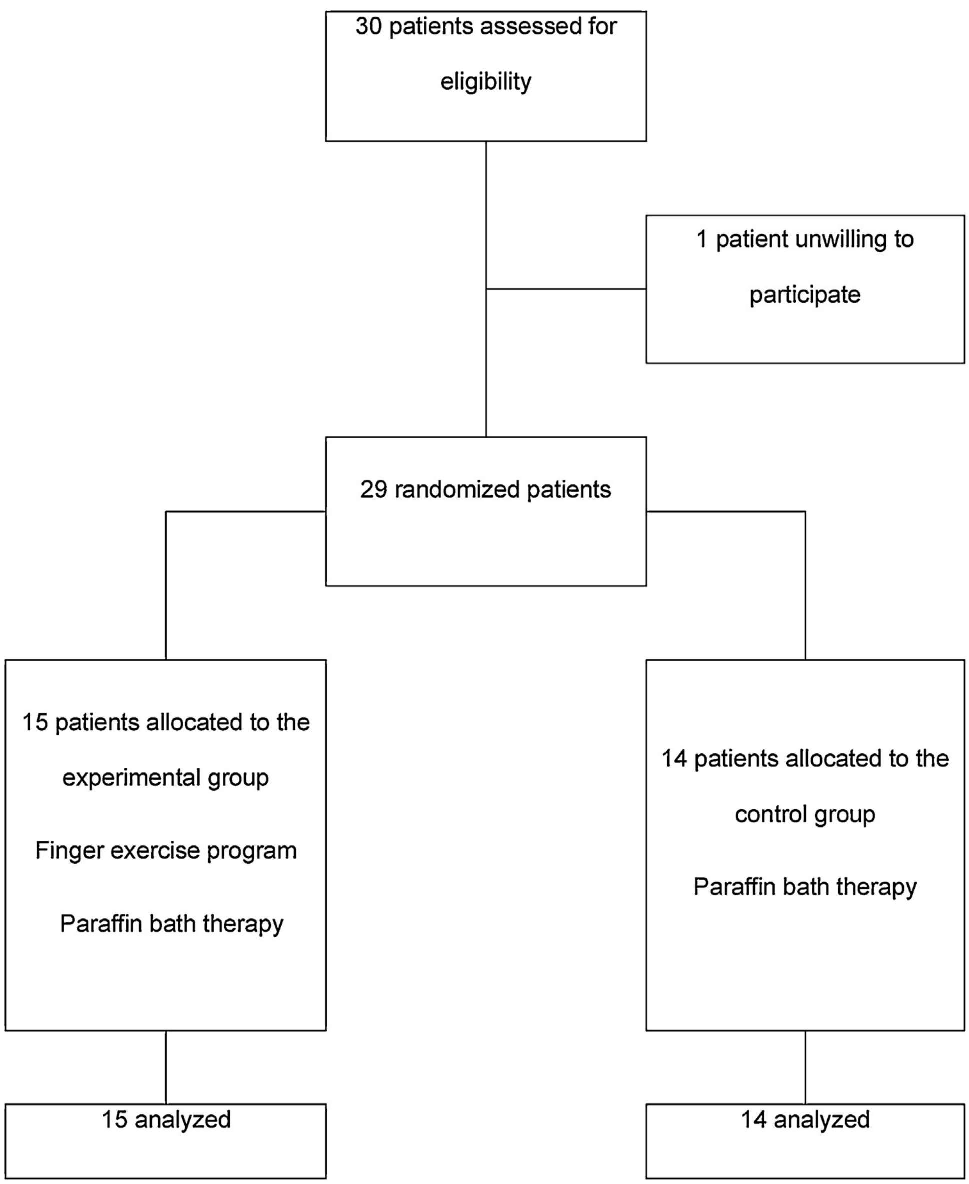


Fig. 1. Flow diagram of this study.

comprised 14 (Fig. 1). Subjects were informed about the tests and signed a written statement in which they formally consented to being enrolled in the study. The study was approved by the Yonsei University Institutional Review Board, and the study complied with relevant regulations, including the Bioethics and Safety Act (registration number: 1041849-201605-BM-028-02).

2.2. Outcome measurements

Baseline and post-intervention data were collected on hand grip strength and the severity of functional impairment. The results of the intervention were assessed on the day after the programs were completed; approximately 10–30 minutes were required for the assessment. The outcomes of the intervention were evaluated based on changes in the two groups. When both hands were affected, the hand with more severe symptoms was used for evaluation.

2.2.1. Hand grip strength

Each subject was given a brief demonstration and verbal instruction for the hand grip strength test using a hand dynamometer (TKK 5101 Grip-D, Takei Scientific Instruments Co. Ltd, Tokyo, Japan); the dynamometer was adjusted to the participant's hand size as needed. Subjects performed 3 trials, with a minimum of 30 seconds rest between each trial. Grip strength was measured in a standing position with the shoulder adducted and neutrally rotated and the elbow slightly extended [19]. The hand dynamometer was held freely without support and did not touch the participant's body. This instrument was reported to have a high criterion-related validity and reliability [19].

2.2.2. Australian/Canadian osteoarthritis hand index (AUSCAN index)

The AUSCAN index consists of a 15-item scale measuring pain (5 items), stiffness (1 item), and function (9 items) during the preceding 48 hours [20]. We used the Korean version of the AUSCAN [21]. The pain subscale assesses the amount of hand pain at rest, and when gripping, lifting, turning, and squeezing objects. The stiffness subscale evaluates stiffness upon waking in the morning. The function subscale assesses difficulty with turning taps and faucets, turning a round doorknob or handle, buttoning a shirt, fastening jewelry, opening a new jar, carrying a full pot with one hand, peeling vegetables and fruits, picking up large heavy objects, and wringing out laundry items. Patients were evaluated using the AUSCAN subscales. Total pain and function subscale scores are calculated by averaging each of the component variables. All items are rated on a 100-mm visual analog scale, and higher scores indicate worse symptoms and function. The AUSCAN index was developed through an interactive process involving expert opinion from rheumatologists, physiotherapists, and orthopedic surgeons, as well as interviews with patients. The test–retest reliability for each of the subscales of the AUSCAN index was found to be acceptable (intraclass correlation coefficient 0.70–0.86), and the construct validity (kappa = 0.68–0.87) was confirmed against the Dreiser Functional Index [17,22].

2.3. Intervention and procedure

Demographic data including age, career length, height, weight, body mass index, and symptom duration were recorded for both groups by a researcher at the company clinic who was blind to group allocation. The primary investigator was not involved in any interventions and was blinded to the group allocation. The raters of the treatment effects were also blinded to the allocation of the interventions. Each intervention (exercise or paraffin bath) was performed in a different room and at a different time because workers have different shifts. Another researcher provided written and verbal information about the disease and its treatments to both groups. All subjects were assigned to an experimental or control group. Paraffin bath therapy was given to both groups, 30 minutes per day, 5 times a week for 8 weeks. The finger exercise program was only conducted in the experimental group. The experimental group was familiarized with the finger exercise program by a therapist. All participants in the experimental group were comfortable after the familiarization period. The experimental group performed the finger exercise program for 30 minutes per day, 5 times a week for 8 weeks. All exercises were performed with 10 repetitions for the initial 2 weeks and 15 repetitions for weeks 3 to 8, with gradual advancement by adjusting the intensity. A physical therapist at the company guided the paraffin bath and exercises.

2.3.1. Paraffin bath therapy

Both groups were treated with dip-wrap paraffin bath therapy. The temperature of the paraffin bath was 50 °C. Subjects dipped the affected hand into the paraffin, removed the hand, and waited for the layer of paraffin to harden and become opaque. Then they re-dipped the affected hand. These procedures were repeated 10 times. When the last layer hardened, the affected hand was covered with a towel for 20 minutes for 8 weeks. In this study, we applied the paraffin onto the participants carefully to avoid the known adverse effects of paraffin, such as heat rash, poor circulation, and skin irritation. There were no adverse effects of paraffin bath therapy in our study. All patients were compliant during the study period.

2.3.2. Finger exercise program

The finger exercise program used the modified methods of Østerås et al. [23]. Exercises 1 and 2 maintain or increase the flexibility of the MCP, PIP, and DIP joints. Exercise 3 increases opponens pollicis strength and grip strength. Exercise 4 strengthens the extensor and abductor pollicis muscles. The purpose was to maintain the thumb web space, increase thumb stability, and counteract the strong pull from the adductor pollicis muscle, combined with the increasing weakness of the opposing thenar intrinsic musculature, which can be seen in individuals with carpometacarpal joint osteoarthritis, thereby leading to thumb adduction deformity. Exercises 5 and 6 increase grip strength.

The program started after the paraffin bath therapy session. Exercises 2–6 were performed with 15 repetitions (Fig. 2). A power web hand exerciser was used for the hand exercise program. Resistance was modified by adjusting the hand position, and depth of finger insertion. The intensity was determined for each individual through 10 repetition-maximum (RM)-testing for pain relief. The maximal weight with which a subject can perform 10 repetitions is referred to as 10 RM. A 10 RM load was assessed for each exercise in the week before the study in all participants. Different resistances were provided to the participants, and the 10 RM test was performed to identify the appropriate level of resistance.

2.4. Statistical analysis

PASW Statistics 18.0 software (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. Descriptive and analytical statistics are presented. Data are presented as mean and standard deviation. Normality was examined using the Kolmogorov–Smirnov test. Differences between time and group were analyzed a mixed-model, 2-by-2 analysis of variance (ANOVA); the within-subjects variable was pre- and post-intervention and the between-subjects variable was experimental and control group. We used Welch's test

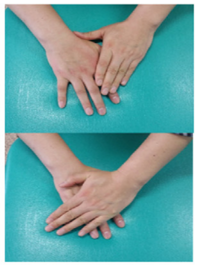
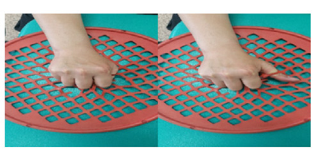
Exercise illustration	Instructions
 1	**Finger stretch:** Lay the affected hand on a flat surface. Use the unaffected hand to apply firm pressure for 30 seconds, stretching the 2nd to 5th PIP and DIP joints. Repeat 2 times for each hand. If the finger joints are painful, stretch one finger at a time; place the 2nd to 4th finger tips between the finger joints of the 2nd finger; press for 30 seconds.
 2	**Roll into a fist:** First, flex the 2nd to 5th DIP and PIP joints alone (keep the MCP extended). Then, flex the MCP. Hold for 5 seconds. Reverse: extend the MCP only, then the PIP and DIP.
 3	**Make an "O-sign":** Grip the power web hand exerciser. Keep the thumb IP and MCP joints slightly flexed throughout. First, open the hand as if grabbing a bottle. Bring the index finger tip to the thumb tip, keeping the MCP, PIP, and DIP joints flexed. Open the hand again ("grasp the bottle"). Repeat with the 3rd, 4th, and 5th fingers.
 4	**Thumb abduction/extension:** Grip the power web hand exerciser. Rest the pronated loose fist on a flat surface. Keep the thumb MCP and IP joints flexed, and abduct/extend the thumb. Hold for 5 seconds.

Fig. 2. Finger exercise program.

to determine the difference between two group means because the group variances were unequal, even if the sample sizes were unequal. We reported 95% confidential intervals (CIs) because these are a range of scores with specific boundaries, which should contain the population mean. This information can be used for decision making or further study [24]. The effect sizes were calculated to determine meaningful changes between groups (differences of means of the experimental and control groups divided by the average standard deviation at baseline). An effect size of ≤ 0.20 indicates a small change, 0.50, a moderate change and 0.80, a large change [25]. Statistical significance was set at a *P*-value < 0.05.

3. Results

The results of hand grip strength and AUSCAN index scores are given in Table 2. The changes in hand grip strength and AUSCAN index score are given in Tables 3 and 4. There were no significant differences for any dependent variables between groups at baseline. After the intervention, all dependent variables at 8 weeks were significantly improved in both groups compared to baseline, except for stiffness in the AUSCAN index in the control group. Statistically significant differences in postintervention values were observed for all dependent variables. In the experimental group, hand grip strength and AUSCAN pain, stiffness, and physical function were improved by 3.52 ± 2.03, 21.6 ± 8.3, 16.8 ± 10.21, and 13.86 ± 4.54, respectively. In the control group, hand grip strength and AUSCAN pain, stiffness, and physical function were improved by 0.57 ± 0.62, 7.85 ± 5.46, 11.42 ± 7.18, and 10.28 ± 14.41. Statistically significant differences between groups in the postintervention values were found for hand grip strength ($P = 0.015$) and AUSCAN index subscale scores (pain, $P < 0.001$; physical function, $P = 0.020$). Large effect sizes of 1.01 and 1.8, 0.6, 0.5 were observed for hand grip strength and pain, stiffness, physical function of the AUSCAN index.

Table 2
Results of hand grip strength and AUSCAN index score.

Variable	Experimental group (n = 15) Mean ± SD	Control group (n = 14) Mean ± SD	t	P	95% CI
Hand grip strength					
Pre	15.62 ± 2.96	15.46 ± 2.31	0.16	0.88	−1.88 to 2.19
Post	19.14 ± 3.88	16.04 ± 2.29	2.60*	0.02	0.65–5.56
t	−6.69**	−3.45**			
P	0.00	0.00			
95% CI	−4.65 to 2.39	−0.93 to 0.21			
Pain					
Pre	63.67 ± 9.42	64.36 ± 9.36	−2.00	0.85	−7.85 to 6.47
Post	42.07 ± 5.26	56.50 ± 6.19	−6.79**	0.00	−18.80 to 10.07
t	10.07**	5.38**			
P	0.00	0.00			
95% CI	17.00–26.20	4.70–11.01			
Stiffness					
Pre	56.33 ± 8.94	57.93 ± 9.34	−0.47	0.64	−8.56 to 5.37
Post	42.47 ± 7.20	50.50 ± 9.20	−2.62*	0.01	−14.30 to 1.76
t	11.80**	1.73			
P	0.00	0.11			
95% CI	11.35–16.39	−1.84 to 16.70			
Physical function					
Pre	67.73 ± 9.42	68.07 ± 6.72	−0.11	0.91	−6.64 to 5.96
Post	50.93 ± 7.01	56.64 ± 5.26	−2.47*	0.02	−10.46 to 0.96
t	6.37**	5.95**			
P	0.00	0.00			
95% CI	11.14–22.46	7.28–15.58			

SD: standard deviation; CI: confidence interval.
* $P < 0.05$.
** $P < 0.001$.

Table 3
Within-group difference in hand grip strength (kg).

	Experimental group (n = 15) Mean ± SD	Control group (n = 14) Mean ± SD	F	P	95% CI
Difference	3.5 ± 2.0	0.6 ± 0.6	26.94**	0.00	−0.93 to 0.21

*$P < 0.05$; **$P < 0.001$; SD: standard deviation; CI: confidence interval.

Table 4
Within-group differences in AUSCAN index (score).

Subscale		Experimental group (n = 15) Mean ± SD	Control group (n = 14) Mean ± SD	F	P	95% CI
Pain	Difference	21.6 ± 8.3	7.9 ± 5.5	25.04**	0.00	4.71–11.01
Stiffness	Difference	16.8 ± 10.2	11.4 ± 7.2	2.65	0.12	7.28–15.58
Physical function	Difference	13.9 ± 4.5	10.3 ± 14.4	0.84	0.37	−1.84 to 16.70

*$P < 0.05$; SD: standard deviation; CI: confidence interval.
** $P < 0.05$.

4. Discussion

This study investigated whether an 8-week finger exercise program combined with paraffin bath therapy can improve hand grip strength and AUSCAN index scores, compared with paraffin bath therapy alone. We found that both groups had significant improvement in hand grip strength and AUSCAN index scores after 8 weeks compared to those at baseline. The experimental group had a statistically significant improvement in hand grip strength and AUSCAN index scores compared with the control group. This finding supports our research hypothesis that a finger exercise program can improve hand grip strength, reduce pain and stiffness, and increase physical function in patients with HO, compared with those who receive paraffin bath therapy alone.

Hand grip strength significantly improved in both groups following treatment: 22.53% in the experimental group and by 3.68% in the control group. While the improvement in the control group may be statistically significant it is not clinically significant. We selected hand grip strength, a variable representing impairment level, as the primary outcome measure for this study because it has been found to better represent actual disability. In the current study, the experimental group had an increase of 3.52 kg and the control group had an increase of 0.57 kg in grip strength. The minimum clinically important difference of the grip strength was a difference of 6.5 kg [26]. The experimental group had a greater increase in grip strength than did the control group. Loss of muscle strength is also an important determinant of pain and disability in patients with osteoarthritis [27,28]. Dilek et al. divided 56 patients with HO into experimental and control groups and conducted paraffin therapy on the experimental group 5 times a week for 3 weeks [29]. Hand grip strength and pain in the experimental group were significantly improved compared with the control group. Strength in their experimental group increased

2 kg and strength in their control group decreased 3.33 kg after treatment. This is consistent with our results, in which a statistically significant increase in hand grip strength was observed in both groups after 8 weeks of treatment. Most therapeutic heating modalities produce analgesia, hyperemia, and relaxed muscle tone. The therapeutic effects derived from these physiological responses are pain relief, reduction of muscle spasm, and increased metabolism [30–32]. In addition, in the experimental group, hand grip strength significantly improved by 83.8% compared with the control group. These findings in our study can be related to the use of stretching and strengthening exercises, as well as the adoption of joint protection behavior taught in the finger exercise program.

Although exercise may be recommended for patients with HO, exercise-based intervention programs are generally used in patients with knee or hip osteoarthritis and have rarely been reported for HO. Nevertheless, a few studies have applied exercise programs in patients with HO [33,34]. Rogers and Wilder used a plate-loaded hand gripper exercise and other exercises that required grasping in elderly patients with HO [35]. The study reported an increase in hand grip strength of approximately 13%. Stamm et al. divided 40 patients with HO into experimental and control groups and applied a hand exercise program in the experimental group for 3 months [9]. The authors reported a significant improvement in the experimental group, with an approximately 25% increase in hand grip strength. This is consistent with the results of our study, in which the group receiving the finger exercise program combined with paraffin bath therapy had a greater increase in hand grip strength than the group receiving paraffin bath therapy alone. This study reported that the 95% CIs of the OA population mean for hand grip strength in the experimental group will be between 2.57 and 3.29. The wider the interval, the more confident we will be that the true population mean will decrease within the aforementioned range.

The AUSCAN pain index score decreased by 33.93% in the experimental group and 12.19% in the control group. The physical function score improved by 24.80% in the experimental group and 16.81% in the control group. The stiffness score decreased by 24.62% in the experimental group and 12.81% in the control group. Improving muscle strength is regarded as the most important means of reducing pain and disability in the treatment of osteoarthritis [36,37]. Our findings indicate that both groups had improved hand grip strength and AUSCAN scores. For AUSCAN pain and physical function, the differences between pretest and posttest values were greater than the proposed cut-off values for minimally clinically relevant differences in the experimental and control groups (1.49 for AUSCAN pain and 1.25 for AUSCAN physical function) [38]. Ours study reports that the 95% CIs of the OA population mean in the experimental group will be between 26.31 and 32.61 for the AUSCAN pain index score, between 24.08 and 32.38 for the physical function score, and between 12.06 and 30.6 for the stiffness score. The wider the interval, the more confident we are that the true population mean will fall within that range.

Dilek et al. reported significant improvement in the AUSCAN pain and stiffness scores when paraffin therapy was used in patients with HO [29]. This differs slightly from the results of our study, in which the control group had a significant improvement in all AUSCAN sub-scores (pain, physical function, stiffness) after the 8-week intervention. The physical function scores significantly improved in our study because decreased pain and stiffness are closely related to functional improvement [39]. In addition, in the experimental group, pain, physical function, and stiffness significantly improved by 63.6%, 31.8%, and 46.5%. After the intervention, the experimental group had greater improvement in hand grip strength than the control group. It is possible that the improvement in hand grip strength induced significant improvement in hand function and pain. In addition, the grip strength of workers in our study is very weak compared normative values [40].

Because the workers constantly perform repetitive tasks every day, they are often exposed to bad movements such as kinking and turning. This movement damages muscles and joints.

Dellhag et al. reported that the combination of paraffin therapy and exercise in patients with rheumatoid arthritis is more effective than paraffin therapy alone [41]. Their study reported that hand function and range of motion significantly improved when paraffin therapy was performed in combination with active hand exercise, compared to the use of paraffin therapy alone. Stamm et al. assessed pain and overall hand function by using a 100-mm visual analog scale after a hand exercise program and joint protection in patients with HO [9]. Many studies reported that exercise relieves the pain for patients with OA [42,43]. The patients had an overall hand function improvement of 65%. This is consistent with our results, in which a combined paraffin and hand exercise program induced significant functional improvement, although loss of function and hand grip strength is permanent in rheumatoid arthritis, unlike osteoarthritis.

In contrast to our results, Stukstette et al. reported that an intensive treatment program (joint protection, self-management, exercises) had no effect [44]. Østerås et al. reported that exercise programs led to only small improvements. However, the age of the subjects of these two studies was higher than in our study, thus the results were different [23]. In addition, since our subjects repeatedly use incorrect movements during their work, the exercises were effective in correcting the imbalances caused by the wrong movements.

Our study has some limitations. First, follow-up measurements were not performed, and the carry-over effect of the finger exercise program could not be determined. Second, our findings should not be generalized to all patients. Our sample size was limited, and all of our patients were male and worked in a factory. Nevertheless, this was a single-blind, randomized, controlled study with a low loss to follow-up rate, enabling its use as a basis for an ideal program. Third, although we provided blinded treatment to the patients, the nature of interventions prohibited pure blinding. The lack of periodic contact with a physical therapist in the control group could have resulted in potential bias, as frequent contact with a physical therapist may explain some of the improvement seen in the experimental group. Moreover, detection bias is likely because the outcome measures were subjective. Finally, our study did not include an intervention for the control group. However, no optimal sham-exercise program was identified, but an educational intervention for the control group might have resulted in limited contrasts between the two groups. For that reason, this study was designed as a practical experiment to compare active intervention with general care. Our study also provides some evidence for the benefit of a finger exercise program, which is taught as a home exercise in many rehabilitation clinics. Future studies should compare the effectiveness of a finger exercise program in improving other parameters such as electromyography or work-related measurements.

5. Conclusion

Our study describes an exercise program that provided positive benefits to patients in a HO clinic. Although Stukstette reported that exercise is not effective, it was effective in our study because they were patient-specific exercises. A finger exercise program combined with paraffin bath therapy seems to be effective in reducing pain, improving physical function, and increasing hand grip strength in HO. Thus, finger exercise can be implemented as a useful adjunct treatment to decrease pain, enhance physical function, and increase hand grip strength in patients with HO, in combination with paraffin bath therapy. Our study supports using this intervention in patients with HO.

Disclosure of interest

The authors declare that they have no competing interest.

References

[1] Haugen IK, Englund M, Aliabadi P, Niu J, Clancy M, et al. Prevalence, incidence and progression of hand osteoarthritis in the general population: the Framingham Osteoarthritis study. Ann Rheum Dis 2011;70:1581–6.
[2] Kjeken I, Dagfinrud H, Slatkowsky-Christensen B, Mowinckel P, Uhlig T, et al. Activity limitations and participation restrictions in women with hand osteoarthritis: patients' descriptions and associations between dimensions of functioning. Ann Rheum Dis 2005;64:1633–8.
[3] Meiners P, Coert JH, Robinson PH, Meek MF. Impairment and employment issues after nerve repair in the hand and forearm. Disability Rehabil 2005;27:617–23.
[4] Feuerstein M, Huang GD, Ortiz JM, Shaw WS, Miller VI, Wood PM. Integrated case management for work-related upper-extremity disorders: impact of patient satisfaction on health and work status. J Occup Environ Med 2003;45:803–12.
[5] Grotle M, Hagen KB, Natvig B, Dahl FA, Kvien TK. Obesity and osteoarthritis in knee, hip and/or hand: an epidemiological study in the general population with 10 years follow-up. BMC Musculoskeletal Disord 2008;9:132.
[6] Jensen V, Bøggild H, Johansen J. Occupational use of precision grip and forceful gripping, and arthrosis of finger joints: a literature review. Occup Med 1999;49:383–8.
[7] Kwok W, Vliet Vlieland TP, Rosendaal FR, Huizinga TW, Kloppenburg M. Limitations in daily activities are the major determinant of reduced health-related quality of life in patients with hand osteoarthritis. Ann Rheum Dis 2011;70:334–6.
[8] Østerås N, Hagen KB, Grotle M, Sand-Svartrud AL, Mowinckel P, Aas E, Kjeken I. Exercise programme with telephone follow-up for people with hand osteoarthritis–protocol for a randomised controlled trial. BMC Musculoskeletal Disord 2014;15:82.
[9] Stamm TA, Machold KP, Smolen JS, Fischer S, Redlich K, et al. Joint protection and home hand exercises improve hand function in patients with hand osteoarthritis: a randomized controlled trial. Arthritis Care Res 2002;47:44–9.
[10] Zhang W, Doherty M, Leeb BF, Alekseeva L, Arden NK, et al. EULAR evidence based recommendations for the management of hand osteoarthritis: report of a Task Force of the EULAR Standing Committee for International Clinical Studies Including Therapeutics (ESCISIT). Ann Rheum Dis 2007;66:377–88.
[11] Zhang Y, Niu J, Kelly-Hayes M, Chaisson CE, Aliabadi P, Felson DT. Prevalence of symptomatic hand osteoarthritis and its impact on functional status among the elderly the Framingham study. Am J Epidemiol 2002;156:1021–7.
[12] Hochberg MC, Altman RD, April KT, Benkhalti M, Guyatt G, et al. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. Arthritis Care Res 2012;64:465–74.
[13] Kloppenburg M. Hand osteoarthritis – nonpharmacological and pharmacological treatments. Nat Rev Rheumatol 2014;10:242–51.
[14] Koopman WJ, editor. Arthritis and allied conditions: a textbook of rheumatology. New York: Lippincott Williams & Wilkins; 2001.
[15] Conditions NCCfC. In: Osteoarthritis: national clinical guideline for care and management in adults. Royal College of Physicians; 2008.
[16] Rogers LQ, Macera CA, Hootman JM, Ainsworth BE, Blairi SN. The association between joint stress from physical activity and self-reported osteoarthritis: an analysis of the Cooper Clinic data. Osteoarthritis Cartilage 2002;10:617–22.
[17] Altman R, Alarcón G, Appelrouth D, Bloch D, Borenstein D, et al. The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hand. Arthritis Rheumatol 1990;33:1601–10.
[19] España-Romero V, Ortega FB, Vicente-Rodríguez G, Artero EG, Rey JP, Ruiz JR. Elbow position affects handgrip strength in adolescents: validity and reliability of Jamar, DynEx, and TKK dynamometers. J Strength Conditioning Res 2010;24:272–7.
[20] Bellamy M, Campbell J, Haraoui B, Buchbinder R, Hobby K, et al. Dimensionality and clinical importance of pain and disability in hand osteoarthritis: development of the Australian/Canadian (AUSCAN) Osteoarthritis Hand Index. Osteoarthritis Cartilage 2002;10:855–62.
[21] Moon KW, Lee SS, Kim JH, Song R, Lee EY, et al. Cross-cultural adaptation, validation, and responsiveness of the Korean version of the AUSCAN Osteoarthritis index. Rheumatol Int 2012;32:3551–7.
[22] Dreiser RL, Maheu E, Guillou G. Sensitivity to change of the functional index for hand osteoarthritis. Osteoarthritis Cartilage 2000;8:25–8.
[23] Østerås N, Hagen KB, Grotle M, Sand-Svartrud AL, Mowinckel P, et al. Exercise programme with telephone follow-up for people with hand osteoarthritis–protocol for a randomised controlled trial. BMC Musculoskeletal Disord 2014;15:82.
[24] Portney LG, Watkins MP. Foundations of clinical research: applications to practice, 3rd ed., Philadelphia: FA Davis Company; 2008.
[25] Cohen J. Statistical power analysis for the behavioral sciences. New York: Routledge/Academic Press; 1998.
[26] Poole JL. Measures of hand function: Arthritis Hand function test (AHFT), Australian Canadian Osteoarthritis Hand Index (AUSCAN), Cochin hand function scale, functional index for hand osteoarthritis (FIHOA), grip ability test (GAT), Jebsen hand function test (JHFT), and Michigan hand outcomes questionnaire (MHQ). Arthritis Care Res 2011;63:189–99.
[27] Dekker J, Boot B, van der Woude LH, Bijlsma JW. Pain and disability in osteoarthritis: a review of biobehavioral mechanisms. J Behav Med 1992;15:189–214.
[28] Dekker J, Tola P, Aufdemkampe G, Winckers M. Negative affect, pain and disability in osteoarthritis patients: the mediating role of muscle weakness. Behav Res Ther 1993;31:203–6.
[29] Dilek B, Gözüm M, Şahin E, Baydar M, Ergör G, et al. Efficacy of paraffin bath therapy in hand osteoarthritis: a single-blinded randomized controlled trial. Arch Phys Med Rehabil 2013;94:642–9.
[30] Myrer JW, Johnson AW, Mitchell UH, Measom GJ, Fellingham GW. Topical analgesic added to paraffin enhances paraffin bath treatment of individuals with hand osteoarthritis. Disability Rehabil 2011;33:467–74.
[31] Stimson CW, Rose GB, Nelson PA. Paraffin bath as thermotherapy: an evaluation. Arch Phys Med Rehabil 1958;39:219–27.
[32] DeLisa JA, Gans BM, Walsh NE. Physical medicine and rehabilitation: principles and practice, Vol. 1. Philadelphia: Lippincott Williams & Wilkins; 2005.
[33] Rogers MW, Wilder FV. Exercise and hand osteoarthritis symptomatology: a controlled crossover trial. J Hand Ther 2009;22:10–7.
[34] Lefler C, Armstrong WJ. Exercise in the treatment of osteoarthritis in the hands of the elderly. Clin Kinesiol 2004;58:13–8.
[35] Rogers MW, Wilder FV. The effects of strength training among persons with hand osteoarthritis: a two-year follow-up study. J Hand Ther 2007;20:244–9.
[36] Dekker J, Mulder PH, Bijlsma JWJ, Oostendorp RAB. Exercise therapy in patients with rheumatoid arthritis and osteoarthritis: a review. Adv Behav Res Ther 1993;15:211–38.
[37] Hurley MV, Scott DL. Improvements in quadriceps sensorimotor function and disability of patients with knee osteoarthritis following a clinically practicable exercise regime. Rheumatology 1998;37:1181–7.
[38] Bellamy N, Wilson C. International estimation of minimally clinically important improvement (MCII75): the Reflect study. Intern Med J 2007;37:36.
[39] Jones G, Cooley HM, Bellamy N. A cross-sectional study of the association between Heberden's nodes, radiographic osteoarthritis of the hands, grip strength, disability and pain. Osteoarthritis Cartilage 2001;9:606–11.
[40] Bohannon RW, Peolsson A, Massy-Westropp N, Desrosiers J, Bear-Lehman J. Reference value for adult grip strength measured with a Jamar dynamometer: a descriptive meta-analysis. Physiother 2006;92:11–5.
[41] Dellhag B, Wollersjö I, Bjelle A. Effect of active hand exercise and wax bath treatment in rheumatoid arthritis patients. Arthritis Care Res 1992;5:87–92.
[42] Juhl C, Christensen R, Roos EM, Zhang W, Lund H. Impact of exercise type and dose on pain and disability in knee osteoarthritis: a systematic review and meta-regression analysis of randomized controlled trials. Arthritis Rheumatol 2014;66:622–36.
[43] Magni NE, McNair PJ, Rice DA. The effects of resistance training on muscle strength, joint pain, and hand function in individuals with hand osteoarthritis: a systematic review and meta-analysis. Arthritis Res Ther 2017;19:131.
[44] Stukstette MJ, Dekker J, den Broeder AA, Westeneng JM, Bijlsma JW, van den Ende CH. No evidence for the effectiveness of multidisciplinary group based treatment program in patients with osteoarthritis of hands on the short-term; results of randomized controlled trial. Osteoarthritis Cartilage 2013;21:901–10.