

JHT READ FOR CREDIT ARTICLE # 063

The Effects of Strength Training among Persons with Hand Osteoarthritis: a Two-Year Follow-up Study

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Osteoarthritis (OA) is the most common of the arthritic joint diseases and frequently affects joints of the hands.¹⁻³ Most persons over the age of 55 have radiographic evidence of OA in at least one hand joint.⁴ It has been reported that 60–70% of persons over the age of 65 seek medical attention for hand OA symptoms.⁵ Hand OA may be characterized by varying degrees of joint deformity, reduced hand strength, decreased function in hand related activities of daily living (ADL), and pain.⁶⁻⁹

As part of the conservative management of hand OA symptoms, hand exercises are commonly used¹⁰⁻¹³ and are recommended by a recent task force.¹⁴ Despite the emphasis on exercise treatment, there has been surprisingly little research into the efficacy of exercise for the management of hand OA symptoms and dysfunction. Only three published

ABSTRACT: Hand exercise is recommended for hand osteoarthritis (OA) management, but few efficacy studies have been published. The purpose of the study was to determine the effects of two years of whole body strength training and gripper exercise on hand strength, pain, and function in adults with radiographic evidence of hand OA. Older adults ($N = 55$; 71.5 ± 6.5 years; 80% female) participated in a two-year, three times per week strength training regimen. Bilateral gripper exercise weight (i.e., isotonic grip strength), isometric grip strength, pain, and self-reported hand, and finger function were recorded at baseline and 24 months. Isotonic grip strength increased 1.94 kg (20.14 kg baseline, 22.09 kg follow-up; $p < 0.0003$). Right and left isometric grip increased 3.62 kg (25.83 kg baseline, 29.45 kg follow-up; $p < 0.002$) and 2.95 kg (22.73 kg baseline, 25.65 kg follow-up; $p < 0.0005$), respectively. Hand pain decreased from 4.77 to 2.62 ($p < 0.006$). Hand and finger function scores showed minimal dysfunction at baseline and follow-up. Results suggest strength training safely increases dynamic and static grip strength and reduces pain in older persons with hand OA.

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randomized controlled trials specifically addressing this issue were located in a search of PubMed on December 2, 2006.^{13,15,16} A yoga regimen was found to improve pain, tenderness, and finger range of motion (ROM), whereas strength showed a statistically nonsignificant trend toward improvement.¹⁵ Although these results are promising, the control group received no treatment, thus limiting the assessment of placebo or social interaction effects. Another trial determined that a combination of joint protection education and seven hand exercises were effective in improving isometric grip strength and global hand function.¹³ The respective control group received OA education only. A recent task force charged with making recommendations for managing hand OA noted the following concerning the above study:

“The comparison group was not an ideal control to address this proposition and since the two elements of treatment were not directly compared we do not know whether the benefit derived from the strengthening exercise, the joint protection program or both.”¹⁴

A third trial compared two types of thumb splints and two types of thumb home exercise programs, in

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combination, among persons with trapeziometacarpal OA.¹⁶ Results demonstrated that both of the splint and exercise combinations were effective in reducing pain and increasing hand strength and function. The trial has similar limitations to the aforementioned study, in that a combination of treatments was used. With this approach it is difficult to discern the relative contributions of the splints and the exercises. It is not known if the exercises alone, or splints alone, would have been as beneficial as the combination. Although all studies have limitations, these clinical trials offer the only known scientifically based evidence of the relationship between exercise and hand OA.

Over 200 persons with radiographic OA participated in a long-term institute-based study of strength training and OA. The strength training program was the sole treatment intervention. Although all participants qualified based on radiographic evidence of OA at one of five sites, those with hand OA were selected for the current analysis ($N = 55$). Gripper machine exercise weight (i.e., isotonic grip strength), maximal isometric grip, hand pain, and self-reported hand and finger function were recorded before and after the intervention. All participants in the current investigation were followed for 24 months. It was hypothesized that participants in a long-term strength training program which included a gripper exercise would demonstrate improvement in isotonic grip strength. Ancillary hypotheses addressed participants' improvements in isometric grip strength, hand pain, and hand and finger function.

METHODS

Data collected from the Clearwater Exercise Study (CES), a pilot investigation conducted to provide supporting data for future controlled trials of exercise training and OA, were analyzed. The CES was conducted from 1998 to 2005 in Clearwater, FL. Initiated by the Arthritis Research Institute of America, the CES was a community-based study. The ambulatory, community-dwelling, uncompensated volunteer study participants were recruited by various outreach methods. Recruitment approaches included newspaper notifications, presentations at local civic club meetings, community organization bulletins, and friend referrals. In addition, local county employees' paycheck stubs included an invitation to participate. An Institutional Review Board approved the study, and all participants signed an informed consent. Before entering the study, participants reported a sedentary lifestyle, with the exception of one participant who did "occasional walking."

CES Strength Training Procedures

Three times per week, study participants followed a structured strength training routine. The goal of the program was to increase muscular strength, muscular endurance, and to a lesser extent, joint flexibility to reduce OA symptoms and improve overall functioning. A fitness trainer supervised the institute-based exercise sessions. The 25- to 30-minute routine incorporated three components: aerobic warm-up, strength training, and cool-down.

For the 5- to 7-minute low intensity aerobic warm-up period, participants self-selected either noninclined treadmill walking (Unisen Star Trac, Tustin, CA) at a self-determined pace of approximately 1.6–5.6 km/h or stationary cycling (Monarch 818E, Varberg, Sweden) at approximately 1.6–4.8 km/h.

The aerobic warm-up was followed immediately by strength training. In consideration of the participants' age and sedentary lifestyle, resistance started at a low level, progressed gradually, and was limited to submaximal efforts. Participants used a multi-station cabled weight stack machine (Endorphin, Pinellas Park, FL) which was custom built to better accommodate elderly participants. The exercise stations included latissimus dorsi pull-down, seated row, shoulder press, biceps curl (elbow flexion), triceps push-down (elbow extension), seated chest press, and a seated stepping exercise. Other strength equipment included a multiplane weight stack hip machine (Endorphin, Pinellas Park, FL) for standing unilateral hip flexion and extension; and two weight plate-loaded pieces from Hammer Strength (Cincinnati, OH): a seated horizontal leg press and a seated hand gripper. The unloaded resistance of the gripper machine (i.e., no weight plates) was approximately 6.3 kg. To reduce the wide spread between the upper and lower handles of the gripper, a wooden block approximately 10 cm high was used under the front edge. A photo of the hand gripper machine, without the wooden block modification, can be seen in [Figure 1](#).

The strength training routine was individualized by adjusting the amount of resistance for each participant using a psychophysical method as follows: after orientation to a given exercise, a light weight was lifted for a set number of repetitions; next the participant provided feedback on the exertion required to move the weight, and adjustments were made for subsequent trials until a near-maximal perceived effort was reached. A slightly lesser weight (e.g., 2.3–4.5 kg) than the near-maximum was then prescribed for the first exercise session.

Participants' responses to resistance-training stress were carefully monitored by the fitness trainer. Once a participant demonstrated the ability to reach a prescribed number of repetitions of a targeted weight for three consecutive visits without undue difficulty, the weight was increased. The number of sets and



FIGURE 1. Hammer strength gripper.

repetitions was standardized and progressed over time. The number of sets and repetitions for weeks 1–4 were 2 × 10, 2 × 15, 3 × 10, and 3 × 15 respectively. Subsequently, this sequence of sets and repetitions was repeated every four weeks.

A 3-minute cool-down on either the treadmill or the cycle ergometer concluded each exercise session.

Participants

The CES' inclusion criteria were: age 40 years and older, of either gender; radiographic evidence of OA at the hands, feet, knees, shoulders, or cervical spine; and not currently engaged in a strength training routine. Exclusion criteria included expecting to relocate from the study area within 24 months of entry, an inability to obtain a release from the participant's primary health care provider, being mentally incapable of providing informed consent, or having a severe mobility limitation that precluded participation in the exercise training. The majority of participants that enrolled were retired from work.

For the purpose of the current analyses only CES participants presenting with grade 2+ radiographic evidence of OA in one or more hand joints were included. These participants must also have completed a minimum of 24 months in the study. A total of 55 participants met these criteria. Mean age of these participants was 71.5 years ± 6.50; 80% were female. Demographic data are presented in Table 1. Distribution of radiographic grades by hand joints are presented in Table 2.

Data Collection and Measures

To determine OA status, each radiograph was graded 0–4 by the ordinal criteria of Kellgren

TABLE 1. Baseline Participant Characteristics (N = 55)

	Mean (SD)	Minimum	Maximum
Age (years)	71.5 (6.50)	54	85
Height (m)	1.6 (0.1)	1.5	1.9
Weight (kg)	73.5 (16.7)	48.1	110.7
BMI* (kg/m ²)	27.7 (4.8)	19.6	38.9

*Body mass index.

and Lawrence¹⁷: 0 = absent, 1 = questionable osteophytes and no joint-space narrowing, 2 = definite osteophytes with possible joint-space narrowing, 3 = definite joint-space narrowing with moderate multiple osteophytes and some sclerosis, and 4 = severe joint-space narrowing with cysts, osteophytes, and sclerosis present. A board-certified radiologist interpreted the radiographs. Participants whose radiographs were interpreted as Grade 0 or 1 were considered free of OA. Those whose radiographs were interpreted as Grade 2, 3, or 4 were classified as having OA. Radiographic evaluation of the hands included bilateral first carpometacarpal, second distal interphalangeal, and third proximal interphalangeal joints. These radiographic sites were chosen by a committee including a rheumatologist and an orthopedic surgeon.

Given that apparent dynamic strength gains of untrained persons during the early stages of a weight training program may be due largely to learning effect,¹⁸ baseline bilateral isotonic grip strength was defined as the 15-repetition weight achieved during the fourth week of training using the gripper machine. All other baseline measures were taken prior to the start of the exercise training.

Isometric grip strength was measured with a Jamar Model 2A3 Dynamometer (Asimow Engineering, Santa Monica, CA) with the handle in position three. Participants were positioned with the arm forward, wrist neutral, and elbow extended. Participants were instructed to squeeze the dynamometer handle as hard as possible. The same fitness trainer conducted all grip testing. One grip measure per hand was taken unless the fitness trainer or participant felt that it was not a good effort, in which case an additional measure was made. Once the fitness trainer and participant were satisfied with the effort, the highest score was recorded.

A 0–10 Numeric Rating Scale of pain (0 = no pain, 10 = severe pain) was completed at baseline and weekly. The pain scale covered seven body areas, including hands. Note that not all participants with radiographically determined hand OA reported hand pain.

The Arthritis Impact Measurement Scale (AIMS2)¹⁹ was completed before entering the exercise program, and repeated at approximately six-month intervals. The AIMS2 is a self-administered arthritis specific questionnaire. Of relevance to the current investigation, Hand and Finger function

TABLE 2. Baseline Radiographic OA Grades by Joint Location Distribution

Joint	Gr 0	Gr 1	Gr 2	Gr 3	Gr 4	Total (2+)*
RDIP	1	9	22	18	5	45
RPIP	6	28	16	4	1	21
RCMC	8	18	18	7	4	29
LDIP	1	18	15	14	7	36
LPIP	13	28	5	5	4	14
LCMC	8	23	10	6	8	24

Gr = grade; R = right; L = left; DIP = second distal interphalangeal joint; PIP = third proximal interphalangeal joint; CMC = first carpometacarpal joint; OA = osteoarthritis.

*Total number of OA hand joints (\geq grade 2) = 169 of 330 joints graded.

were measured by the AIMS2. Five ADL-related factors included writing with a pen or pencil, buttoning a shirt or blouse, turning a key in a lock, tying a knot or bow, and opening a new jar of food. Each AIMS2 question was answered on a 1–5 scale of ability to do the task during the past month as follows:

1 = all days; 2 = most days; 3 = some days; 4 = few days; and 5 = no days.

Once scored, AIMS2 results are normalized to a 0–10 scale, with 0 = “good health status” and 10 = “poor health status.”

Statistical Analysis

Frequencies and means were used to describe baseline characteristics of the study sample. Demographic information and clinical factors such as gender, age, and body mass index were summarized to provide general information about the study participants. Our primary study objective was to quantify the change in isotonic grip strength. A one-sample t-test assessed whether the mean change in scores (baseline—follow-up) was significantly different from zero. Values for p less than or equal to 0.05 were considered statistically significant. SAS version 9.1.3 software was used for all statistical analyses.

RESULTS

Fifty-five participants had complete data for isotonic grip strength. Due to missing data, 29 of these participants’ isometric grip strength scores and 28 participants’ hand and finger function scores were available for analysis. Pain scores from a subgroup of 13 participants that reported baseline hand pain of 3 or higher (defined as symptomatic hand OA) were analyzed.

Participants significantly increased their isotonic grip strength 1.94 kg (20.14 kg baseline, 22.09 kg follow-up; $p < 0.0003$). Among participants aged 55–70 years ($N = 25$), isotonic grip strength increased 1.42 kg (20.14 kg baseline, 21.83 kg follow-up; $p < 0.07$). Among participants ages 71–85 years

($N = 29$), isotonic grip strength increased 2.35 kg (19.94 kg baseline, 22.29 kg follow-up; $p < 0.002$).

Right isometric maximal grip strength increased 3.62 kg (25.83 kg baseline, 29.45 kg follow-up; $p < 0.002$). Left isometric maximal grip strength increased 2.95 kg (22.73 kg baseline, 25.65 kg follow-up; $p < 0.0005$). Among participants aged 55–70 years, right and left isometric grip increased 2.69 kg (29.92 kg baseline, 32.40 kg follow-up; $p < 0.15$) and 3.31 kg (25.87 kg baseline, 29.17 kg follow-up; $p < 0.007$), respectively. Among participants aged 71–85 years, right and left isometric grip increased 3.78 kg (24.26 kg baseline, 28.04 kg follow-up; $p < 0.02$) and 2.13 kg (21.42 kg baseline, 23.55 kg follow-up; $p < 0.07$), respectively.

Among participants with a baseline hand pain score of 3 or higher, hand pain decreased from 4.77 to 2.62 ($p < 0.006$). Among participants aged 55–70 years with a baseline hand pain score of 3 or higher ($n = 6$), hand pain decreased from 4.67 to 2.17 ($p < 0.06$). Among participants aged 71–85 years with a baseline hand pain score of 3 or higher ($n = 6$), hand pain decreased from 5 to 3 ($p < 0.09$).

No significant change was observed for self-reported hand and finger function. The AIMS2 is interpreted based on a 0–10 score, with 0 = “good health status” and 10 = “poor health status.”¹⁹ The mean Hand and Finger subscale scores were less than 1 at both time points (minimum was 0 and maximum was 4). This result indicates there was minimal perceived hand and finger dysfunction in these participants at baseline and follow-up, creating a floor effect.

There were no reported hand injuries or cardiac events associated with the CES.

DISCUSSION

The results of this investigation suggest that older adults with radiographic hand OA are able to significantly improve hand strength during a two-year general strength training program. At baseline 24% of participants (13/55) reported hand pain of 3 or higher on the 0–10 scale. The study sample demonstrated that radiographic hand OA is more common than symptomatic hand OA. Among this smaller group of participants, significant reductions in hand pain were observed.

As expected, participants in the younger age group (55–70) demonstrated greater isotonic and isometric hand strength at both time points versus the older age group (71–85). Among the older age group, the absolute amount of isotonic and isometric hand strength increase was slightly higher than that of the younger age group. Among the symptomatic hand OA participants, both age groups decreased hand pain in a similar manner (i.e., 2.5 and 2.0 points in the younger and older age groups, respectively).

These age group findings suggest that even participants of advanced age can improve hand strength and decrease hand pain.

The lack of any decline in hand and finger function, together with the decrease in hand pain, suggests that the exercises were safe and well tolerated by the participants.

For the current investigation hand gripper exercise cannot be evaluated independent of the whole body strength training routine. It is conceivable that gripping the bars used during other upper extremity exercises (e.g., lat pull-down, seated row, chest press, etc.) could have been adequate to see these benefits even without the gripper exercise. Possibly the gripper exercise alone would have had similar benefits. Additional trials of hand exercise independent of other exercise modalities, and vice versa, are needed to determine the intervention responsible for hand strength gains.

Another limitation is the lack of a nonstrength training control group. It cannot be ruled out that the benefits of the strength training program were, in whole or in part, influenced by placebo or social interaction effects of the group setting. Although placebo or social effects are unlikely to account for any increase in strength, especially in older adults having aged two years, it cannot be ruled out as a potential factor in pain improvement. Finally, hand and finger dysfunction was minimal, thus limiting the ability to comment on ADL-related hand function. It is not known if the results of this investigation can be generalized to hand OA patients with greater hand dysfunction. Clinicians should continue to consider the unique symptoms, needs, and expectations of the individual patient when tailoring an exercise prescription.

Future trials of the efficacy of exercise as treatment for hand OA should be designed to address the limitations of this and other trials.^{13,15,16} Hand exercise routines should be evaluated independent of other interventions. Potential placebo and social effects should be controlled. Hand OA participants with moderate to high levels of hand dysfunction should be recruited so that ADL-related hand function can be assessed along with strength and pain. Instrumentation is another important area to consider.²⁰ A validated instrument specifically designed for hand arthritis trials, such as the 15-item AUSCAN Index^{21,22} or a combination of instruments²³ may be most appropriate when conducting hand OA trials. Objective validated physical measures of ADL related hand function (e.g., dexterity tests) should also be considered.

CONCLUSIONS

In summary, the results of this investigation indicate that older persons with radiographic evidence of

hand OA and minimal baseline hand and finger dysfunction can improve static and dynamic grip strength by participation in whole body strength training that includes a gripper exercise. Those with symptomatic hand OA were able to reduce hand pain while improving strength. Hand and finger function showed a floor effect and it is suggested future trials recruit participants with greater hand dysfunction. Although these results are promising, more research is needed to verify and expand these and other findings and to clarify the proper role of exercise in the management of hand OA.

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Quiz: Article # 063

Record your answers on the Return Answer Form found on the tear-out coupon at the back of this issue. There is only one best answer for each question.

- #1. The primary outcome measure of the study was
 - a. functional improvement
 - b. pain reduction
 - c. isometric grip strength
 - d. isotonic grip strength
- #2. The study showed that the strengthening program resulted in
 - a. increased grip strength, increased function, no change in pain
 - b. decreased pain, increased grip strength, increased function
 - c. decreased pain, increased grip strength, no increase in function
 - d. no significant change in grip strength, pain, or function
- #3. The following is true regarding the patients included in the study
 - a. the only intervention was the overall strengthening program

- b. the only intervention was the hand gripper exercise program
 - c. the exercise program was supplemented by physical agent modalities
 - d. the patient population was a random distribution of OA patients ranging from 30 to 80 years old
- #4. A _____ made the diagnosis of OA for those included in the study
 - a. rheumatologist
 - b. radiologist
 - c. hand surgeon
 - d. hand therapist
- #5. Baseline grip strength data were collected
 - a. upon the initial visit
 - b. during the 4th week after the start of the exercise program
 - c. on the 2nd visit
 - d. at the completion of one week's exercise

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