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Original Article

Intervention study of finger-movement exercises and finger weight-lift training for improvement of handgrip strength among the very elderly

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ABSTRACT

Objectives: To examine the effects of finger-movement exercises and finger weight-lift training on handgrip strength and Activities of Daily Living Scale (ADLS) values.

Methods: A total of 80 very elderly adults (aged ≥80 years) were assigned to either an intervention group ($n = 40$) or a control group ($n = 40$). Subjects in the intervention group performed finger-movement exercises and weight-lift training for a period of 3 months, while subjects in the control group received no intervention, and were unaware of the interventions received in the other group.

Results: After completing 3 months of finger-movement exercises and weight-lift training, the average handgrip strength of the 40 participants in the intervention group had increased by 2.1 kg, whereas that in the control group decreased by 0.27 kg ($P < 0.05$). After receiving intervention, the number of subjects in the intervention group with an ADLS score >22 points decreased by 7.5% ($P < 0.05$, vs. pre-intervention).

Conclusions: The combined use intervention with finger-movement exercises and proper finger weight-lift training improved the handgrip strength and ADLS values of very elderly individuals. These rehabilitation exercises may be used to help the elderly maintain their self-care abilities.

1. Introduction

As a greater proportion of the population reaches an advanced age, methods than can assist in healthy aging have become more important than ever. One of the endpoints used to assess healthy aging is the ability maintain self-care abilities for as long as possible. Handgrip strength is commonly used as a surrogate measurement of overall muscle strength,

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and among elderly individuals, handgrip strength is associated with health-related quality of life [1], the ability to perform activities of daily living (ADLs) [2], bone mineral density and the incidence of vertebral fracture [3], length of hospitalization [4], psychological and social health [5], and the development and prognosis of certain diseases [6–8]. Additionally, handgrip strength is useful for assessing the general health of older adults, and predicting both disability [8] and mortality [9]. For example, results of a 9.5-year observational study of 555 adults aged >85 years showed that handgrip strength was a predictor of mortality from all causes in the very elderly [10].

Handgrip strength declines with age, and especially among individuals aged >80 years. A study of 8342 Danes aged 46–102 years, showed linear declines in handgrip strength with age between 46 and 85 years, and rapid declines after 85 years [11]. The handgrip strength of individuals aged 80–89 years is 37% less than that of individuals aged 30 years [12], and declines with average losses of 1.53 kg/year among men and 0.85 kg/year among women aged 85–89 years [10]. Handgrip strength is an important factor which impacts an elderly individual's ability to perform ADLs, which typically require a maximum handgrip strength ≥9 kg [2].

While various interventions for improving muscle strength have been reported, almost no information has been reported on such interventions in very elderly individuals (aged ≥80 years). However, some studies have suggested that exercise during later life improves muscle strength and physical function [13], and that older adults who are physically active can regain some amount lost strength as they age [14]. Skilled finger-movement training can be used to improve an individual's ability to control submaximal pinch force and hand function [15]. Another study indicated that higher levels of physical activity can improve grip strength in older adults, and emphasized that greater attention must be given to designing interventions which may improve grip strength [16].

Finger-movement exercises are traditionally used during the rehabilitation of hand functions, and interventions based on finger-movement exercises and finger weight-lift training have been accepted by older adults in Hanzhou. We conducted our current study to evaluate the effects of finger-movement exercises and finger weight-lift training on the self-care abilities of very elderly subjects (aged ≥80 years). We used our finger exercise and weight-lift baseline data to determine the long-term effects of these exercise methods on improving handgrip strength.

2. Methods

2.1. *Research design*

This was an experimental study which enrolled subjects aged ≥80 years (range, 80–93 years). Participants in the intervention group performed finger-movement exercises combined with finger weight-lift training for a period of 3 months. Participants in the control group were recruited from a different social welfare institution than participants in the intervention group. Control group subjects did not receive intervention, and were not aware of the intervention group. The study was approved by the ethics committee for the School of Nursing, Hangzhou Normal University.

2.2. *Sampling and sample size*

Subjects enrolled in the intervention and control groups were recruited from Hangzhou No. 2 Social Welfare Courtyard and Hangzhou Social Welfare Center, respectively. The inclusion criteria for this study were: (1) age ≥80 years, (2) conscious and able to communicate in Chinese, (3) no upper-limb defects and able to undergo handgrip strength measurements, (4) no contraindication for hand exercise, (5) no disease that would restrict the application of hand force, and (6) ability to remain in a sitting position while performing finger exercises and weight-lift training. The exclusion criteria were: (1) cardiac function rating of ≥ class III, (2) severe cognitive impairment, (3) upper limb pain, severe arthritis, or nervous or cardiovascular disease that prohibited performance of handgrip measurements or exercise, and (4) any other condition that restricted the application of hand force.

The statistical power and effect size in this study were determined using SPSS for Windows, Version 16.0. Chicago, IL: SPSS Inc. The initial measurements of handgrip strength of study participants were taken at the welfare institutions prior to the start of intervention, and the results showed a standard deviation (SD) and permissible error of 4.5 and 0.15, respectively. P-values < 0.05 were considered statistically significant. Based on the t-test sample size calculator developed by Gao [17], the estimated required sample size for this study was 29 individuals. Assuming an attrition rate of 10% in the repeated-measures studies, we selected a sample size of 40 subjects for each group.

2.3. *Intervention*

Study participants in the control group received no intervention. The 40 participants in the intervention group were assigned to one of four subgroups, and each subgroup selected a leader. The leader gathered the participants into the exercise room every morning at 10 a.m. with the assistance of the caregiver, and then led the participants in the exercises. The exercises were conducted daily, and consisted of 20 min of finger-movement exercises and 10 min of finger weight-lift training. When the exercises were completed, the leader of each group recorded the performance of each participant, including how long the participant performed the exercises, whether or not the exercises were completed, and how the participant felt about the physical effects at the end of the exercises. The study investigators joined the exercise groups every Monday, Wednesday, and Friday, and student nurse volunteers joined on weekends.

To help ensure compliance of the participants with the exercise program, the investigators inspected the performance record of each participant in the intervention group every weekend, measured handgrip strength every month, and presented gifts to group members to encourage their participation. To avoid the influence of weather, the exercises were conducted between September and November, when the weather was relatively mild and stable.

2.3.1. *Finger-movement exercises*

The set of finger-movement exercises was designed based on previously suggested methods [18] and the physical condition of the participants. The set consisted of 11 movements: palm and opisthenar massage, pinching, stretching and clenching, filliping, crooking, finger counting, pairing, pressing, digital root hitting, wrist pressing and turning, and hand swinging. Each movement was repeated 20 times. After spending one week to become familiar the movements, the participants performed one cycle of exercises every morning.

2.3.2. *Finger weight-lift training*

A "training bag" capable of holding four 600-mL plastic bottles was designed and constructed. Following completion of the finger-movement exercises, the weight-lift intervention was conducted as follows. Each participant placed their arms at their sides, keeping their arms and wrists fixed. Then, they crooked the straps of the training bag with their fingertips and lifted the bag with the force produced by their fingers. They then relaxed their fingers and lifted the weight again, repeating the lifting exercise 50 times with 1 or 2 breaks periods, if needed. This training regimen was conducted once per day. The weight of the training bag was gradually increased from one to four bottles that weighed a total of 2.5 kg. Participants spent 1 week of training adapting to the weight.

2.4. Measurements

The handgrip strength of each individual in the control and intervention groups, and their ability to perform ADLs (herein referred to as "ADL ability") were measured before and at 3 months after starting intervention. Other baseline information was obtained through questionnaire surveys of our design.

2.4.1. *ADL ability*

ADL ability was measured with the Activities of Daily Living Scale (ADLS), which was constructed by Lawton and Brody. The overall scale consists of six physical self-maintenance (PSMS) and eight instrumental activities of daily living (IADL) scales. The PSMS scales measure a subject's ability to perform tasks of toileting, feeding, dressing, grooming, physical ambulation, and bathing. The IADL scales measure abilities to use the telephone, shop, prepare food, perform housekeeping chores, wash clothing, be responsible for taking medication, handle finances, and provide for a mode of transportation [19]. Each item is scored on a scale of 1–4 points, with a total possible score of 14–56 points. The ADLS is widely used for assessing the self-care abilities of elderly Chinese [20].

2.4.2. *Hand dynamometry*

Handgrip strength was measured using a CAMRY-EH101 hand dynamometer (Henqi, Guangdong, China) This device functions as a high-precision strain sensor, and can accurately detect a maximum handgrip strength of 90 kg, in subunits of 0.1 kg. When a force is exerted in a continuous manner, the screen displays both the value of the strength as it varies, and the maximum handgrip strength. The dynamometer can be zeroed automatically and allows the user to store and search information. A knob on the handle of the device can be adjusted for five different grip distances as indicated by different tick marks. Based on the physical condition of the study participants, our studies were conducted using the second tick mark (grip distance) setting on the instrument.

The test-retest reliability of the CAMRY-EH101 hand dynamometer was determined by tests conducted with 33 volunteers recruited from the Hangzhou Normal University School of Nursing, and the value was found to be 0.993. A Jianmin handgrip strength meter (used in China's national health check program) was provided by the University's School of Physical and Health Education, and used as a reference to measure parallel forms reliability; the result was 0.987.

Participants were seated in the standard position recommended by the American Society of Hand Therapists (ASHT), with their feet flat on the floor, knee and hip joints flexed 90°, shoulder in adduction and neutral rotation, elbow flexed 90°, upper arm flat with chest, forearm in a neutral position, and the wrist between 0° and 30° of dorsiflexion and 0° and 15° of ulnar deviation [21,22].

Studies have shown that the maximum handgrip strength measured when using a rapid exertion of force is greater than that measured when using a slow exertion by the same subject [23]. Additionally, handgrip strength values measured by use of visual feedback and verbal stimuli were 9.7% and 7.7% greater, respectively, than those measured without such methods [23]. Providing standardized instructions to study participants is crucial for obtaining accurate measurement results. Therefore, we conducted this research using standardized measurement instructions, and avoided using visual feedback and verbal stimuli.

The study subjects were taught the test procedures and proper use of the hand dynamometer. Prior to starting the tests, the subjects were asked to complete a 5-min warm-up exercise of their shoulder, elbow, wrist, and finger joints, and also participated in 1–3 three exercises involving mild to moderate exertion of handgrip force. After completing the warmup exercises, each participant had their blood pressure and heart rate measured to ensure that they could safely take the test. Each subject had 1–2 s to prepare before taking the handgrip test. Once told to begin the grip, the subject rapidly increased their grip strength to the best of their ability, and then continued exerting as much force as possible until they were unable or unwilling to continue. After a break of 5 min, the subject was tested a second time. The larger value obtained from the two tests was recorded as the handgrip strength of the subject. All measurements taken before and after intervention were conducted between 9 and 10 a.m.

3. Data analysis

The data in our study were analyzed using SPSS 16.0 for Windows, Version 16.0. Chicago, Il: SPSS Inc. The ADLS and handgrip strength data, including the pre-intervention (baseline) data and data obtained after 3 months of intervention, were for the two groups were compared using the χ^2 test for enumeration data and the Mann–Whitney test for continuous data. P-values < 0.05 were regarded to be statistically significant.

4. Results

4.1. Recruitment and participant characteristics

Five of the 88 very elderly adults who originally volunteered to participate in this study did not meet the eligibility criteria. The 83 eligible participants were assigned to either the intervention group ($n = 42$) or the control group ($n = 41$). To avoid mutual influence, the participants in the two groups were recruited from two different local institutions which had similar management models, and the members of the control group were kept unaware of the existence of an intervention group. During the 3-month period of this study, one participant in the control group died from disease, and two participants in the intervention group did not complete the study due to personal reasons. The participants who completed the study included 40 subjects in the intervention group and 40 subjects in the control group. Participants in both groups were assessed with the ADLS test, the hand dynamometer, and a questionnaire of our design. The baseline characteristics of the participants in both groups are presented in Table 1.

Table 1 – Participant characteristics at baseline.[a]

Characteristic	Experimental group ($n = 40$)	Control group ($n = 40$)	P-value
Age (y)			0.87
80–84	30 (75.0%)	28 (70.0%)	
85–89	7 (17.5%)	8 (20.0%)	
90–93	3 (07.5%)	4 (10.0%)	
Gender			0.34
Male	11 (27.5%)	15 (37.5%)	
Female	29 (72.5%)	25 (62.5%)	
Education			0.14
≤Primary school	19 (47.5%)	12 (30.0%)	
Junior high	14 (35.0%)	13 (32.5%)	
≥Senior high	7 (17.5%)	15 (37.5%)	
Physical exercise[b]			0.66
Frequent	24 (60.0%)	20 (50.0%)	
Occasional	10 (25.0%)	13 (32.5%)	
None	6 (15.0%)	7 (17.5%)	
Major disease[c]			0.95
Hypertension	27 (64.5%)	19 (44.5%)	
Diabetes	7 (14.5%)	4 (10.0%)	
Coronary disease	14 (35.5%)	10 (25.0%)	
Hearing			0.362
Good	18 (45.0%)	19 (47.5%)	
Minor loss	17 (42.5%)	12 (30.0%)	
Severe loss	5 (12.5%)	9 (22.5%)	
Eyesight			0.612
Good	18 (45.0%)	18 (45.0%)	
Minor loss	14 (35.0%)	17 (42.5%)	
Severe loss	8 (20.0%)	5 (12.5%)	
Handgrip strength (kg)			0.86
≤16	15 (37.5%)	17 (42.5%)	
16.1–20.0	12 (30.0%)	10 (25.0%)	
20.1–35.6	13 (32.5%)	13 (32.5%)	

[a] Values are presented as n (%). No significant differences were found between the two groups.
[b] Frequent refers to exercises that last ≥30 minutes and are conducted ≥3 times/week. Occasional refers to exercises conducted <3 times/week.
[c] "%" refers to the proportion of participants with the specific disease in the entire group.

4.2. Handgrip strength

The pre- and post-intervention handgrip strength values of participants in both groups are shown in Table 2. The average post-intervention value in the intervention group was higher than that in the control group.

4.3. ADLS scores

The mean pre- and post-intervention ADLS scores of the two groups are shown in Table 3. The total possible points in the ADLS evaluation ranged from 14 to 56, and the participants in each group were divided into subsets of normal (14–16 points), minor loss (17–22 points), and severe loss (>22 points). Prior to the intervention, the number of participants in each subset was not significantly different between the two groups. However, following completion of the study, there were more low ADLS scores in the intervention group than in the control group. In other words, the ADLS scores suggested that participants in the intervention group had a greater ability to conduct daily living activities compared to participants in the control group.

5. Discussion

5.1. Similarity of baseline characteristics between the two groups

A total of 80 very elderly adults (54 females, 26 males; age range, 80–93 years) participated in this research. Participants in both groups were similar in terms of their age, gender, education level, major disease prevalence, and exercise habits ($P > 0.05$). Additionally, there was no significant difference between the two groups regarding their average handgrip strength or ADLS value at baseline. The two groups were recruited from two different social welfare institutions in Hangzhou, and both institutions were administered by the Hangzhou Municipal Bureau of Civil Affairs. Both institutions had similar intake criteria, charging standards, accommodation environments, serving staff, and management models.

Table 2 – Handgrip strength in both groups before and 3 months after starting intervention in the treatment group (mean ± SD).

Timing	Intervention group ($n = 40$)	Control group ($n = 40$)	P-value[a]
Pre-intervention	19.17 ± 6.0	18.83 ± 6.7	0.81
Post-intervention	21.27 ± 5.6	18.56 ± 6.6	0.04
P-value[b]	0.000	0.004	

[a] Between intervention and control groups.
[b] Between pre- and post-intervention differences within each group.

Table 3 – Measured ADLS scores before and 3 months after starting intervention in the treatment group, *n* (%).

ADLS scores	Intervention group ($n = 40$)	Control group ($n = 40$)	P-value
Pre-intervention			0.643
14–16	27 (67.5%)	23 (57.5%)	
17–22	8 (20.0%)	11 (27.5%)	
22–31	5 (12.5%)	6 (15.0%)	
Post-intervention			0.043
14–16	28 (70.0%)	22 (55.0%)	
17–22	10 (25.0%)	8 (20.0%)	
22–37	2 (05.0%)	10 (25.0%)	

They also had similar general conditions and were considered comparable.

5.2. *Effects of intervention on handgrip strength and ADLS scores*

Study participants who performed finger-movement exercise and weight-lift interventions for 3 months had significantly increased handgrip strength scores (Table 2) and decreased ADLS values (Table 3) compared to participants in the control group. Compared to the mean values obtained prior to intervention, the mean handgrip strength in the intervention group increased by 2.1 kg after 3 months, whereas the mean strength in the control group declined by 0.27 kg ($P < 0.05$ between groups). The ADLS scores in the two groups also differed after the intervention, with fewer participants in the intervention group than in the control group having ADLS scores >22 points ($P < 0.05$).

Our results are similar to those in Vinoth's study of 14 elderly subjects who performed skilled finger-movement exercises [15]. Skilled finger-movement training improves an elderly individual's ability to control submaximal pinch force, hand steadiness, and manual speed Other studies have shown that exercise programs can also improve age-related regression of hand function among elderly individuals [13–15]. In our study, finger-movement exercises improved manual reaction and dexterity, and when combined with finger weight-lift training, also improved handgrip strength in older adults.

In our study, the average handgrip strength in the control group declined by 0.27 kg after 3 months. This result was similar to findings reported by Ling et al. [10], who showed that the handgrip strength values of adults aged >85 years declined at an average rate of 0.85–1.53 kg/year. We found that the handgrip strength and ADLS values of very elderly adults could be improved by intervention. Handgrip strength is associated with health-related quality of life [1] and ADL ability [2]. Further studies are needed to determine whether finger-movement exercises and weight-lift training can delay the decline of handgrip strength in old age. Such data could be used to improve digital function and extend the time-frame during which adults can care for themselves.

5.3. *Compliance of very elderly adults with the intervention training*

The subjects in our study were voluntary participants who were recruited from welfare institutions. After negotiating with the managers of these institutions, the investigators initiated finger-movement exercises and weight training as part of the daily activities. The use of this approach facilitated our research and also management of the intervention. Finger-movement exercises are a popular practice among the elderly population in Hanzhou; additionally, the exercise bag that we constructed was safe, useful, and readily accepted by the older adults. The participants in our study showed good compliance with intervention instructions during the during the 3-month study period. Our findings show that such intervention could be incorporated as a daily exercise routine for older adults.

5.4. *Limitations of this study*

This study has several limitations that should be mentioned. First, the interventions consisted of finger-movement exercises and weight-lift training; both were implemented simultaneously in the intervention group without respective control designs to distinguish the effect of either intervention by itself. Second, only the values for handgrip strength before and after intervention were analyzed, and not the continuous variables in the process. Third, we did not analyze the effectiveness of intervention based on the subject's gender, age or initial handgrip ability. Fourth, the intervention period used in this study was relatively short. Further studies and observations are needed to confirm our results and determine whether the types of intervention used in this study can further improve handgrip strength and ADL scores.

6. Conclusion

Finger-movement exercises are commonly employed among residents in Hanzhou, China. These exercises are noninvasive and easy to apply in both an individual's home or a welfare institution. The combined use of finger-movement exercises and proper finger strength training can effectively improve handgrip strength and ADLS values. This approach could be used as a rehabilitation exercise to help the elderly maintain their self-care abilities as long as possible.

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Conflicts of interest statement

The authors declare that they have no conflict of interest.

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