Within-Patient Effects of a Novel Hand Exercise Device and Therapy Program for Patients with Hand Osteoarthritis: A Quasi Experimental Study

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Abstract

Background: Arthritis is the most frequent cause of disability, comprising of more than 100 rheumatic diseases and conditions which affect 50 million people worldwide. The most common type of arthritis is osteoarthritis (OA), a degenerative disease impacting primarily hand, knee, spine, and hip joints in individuals 65 and older. Symptomatic hand OA, a serious health problem, has important daily functional limitations related to pain, weaker grip strength, and activities requiring precise finger flexion and grip.

Purpose: The purpose of this study was to determine if a specific hand exercise device improves grip strength, hand function, and joint pain in those with hand OA who are 65 and older.

Study Design: This was a prospective cohort and quantitative study. The ViEx™ exercise device (U.S. patents 9,277,107 and 9,630,058) was invented for people with hand OA. Twenty participants with self-reported physician-diagnosed hand OA, 65 years and older, exercised with the ViEx™ every day for four weeks. The outcome measures were hand function via the QuickDASH Questionnaire, grip strength via a hand dynamometer, and pain via a Wong Baker scale journal.

Results: Both grip strength and hand function improved in 95% of participants (average improvement 28% and 48% respectively). Pain improved in 70% of participants (average improvement: 48%) after using the ViEx™.

Conclusion: These findings suggest that precise individual finger exercises with the ViEx™ may significantly benefit hand OA patients by increasing grip strength, improving hand function, and reducing joint pain. Future controlled trials are necessary.

Keywords: occupational therapy, hand exercise, hand osteoarthritis, hand pain, grip strength

Introduction

Arthritis is a public health challenge, affecting approximately one in five people in the United States, and osteoarthritis (OA) is the most common form of arthritis, affecting more than half of those 65 years or older.[1] While experts traditionally recommend heat, avoidance of painful tasks, orthoses for support, rest and relaxation[2] for those with hand OA, emerging studies have shown that hand exercise can alleviate symptoms, such as joint pain, reduced hand function, limitations in range of motion, and weaker grip strength.[3–5] Yet, the question remains which tools or methods of exercising are effective and useful. Studies of hand OA have evaluated various exercise programs and concluded that, in general, hand exercises improve grip strength, hand function, and reduce joint pain.[6,7]

The number of studies of hand OA is noticeably fewer than those of either hip or knee OA, despite the fact that hand OA is a common and debilitating health problem.[9,10] Exercise, reducing pain and immobility is evidently critical for hand OA patients.

String instrument musicians, including piano and wind instrument musicians are instructed in the use of an arched/curved finger for playing. The approach to a rehabilitation device "that focuses specifically on the affected joints, motivates and encourages compliance . . . and provides effective results, is needed."[8] The arched position of the fingers used is significant: string instrument musicians, including piano and wind instrument musicians are instructed in the use of an arched/curved finger for playing. Additionally, the single finger approach is unique, as most other exercises utilize the entire hand or all fingers at once, causing compensation and lack of focus on each individual finger.

This study utilizes the ViEx™ (U.S.Patent & Trademark Office Patent Numbers 9,277, 107 and 9,630,58), a new hand exercise device invented which is a unique strengthening device for patients with hand OA as it requires precise finger flexion that employs the use of the entire individual finger, including all joints: the metacarpophalangeal joint (MP), the distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints, as well as the carpometacarpal (CMC1) thumb joint.

Previous studies of hand exercise for hand OA have used gripping tools, such as a ball or therapeutic putty.[11,12] However, pressing violin strings down on the violin targets the specific joints most commonly affected by arthritis; the ViEx™ relates to the violin in that they both involve compressing strings with individual fingers, but the ViEx™ allows for exercise with all fingers and thumbs and can be used by anyone.

Studies specifically testing general whole-hand exercises for OA patients have shown improvements in grip strength, function, and pain. Eight studies that tested hand OA patients doing exercises found improved grip strength and decreased pain. [7] Additional studies utilizing exercise programs with hand OA subjects found improvements in grip strength as compared to subjects who did not receive the exercise treatment.[7,12] In another study, it was concluded, “older adults who exercised regularly demonstrated a 32% reduction in functional decline” -- this study measured function by assessment of regular daily tasks.[13] Again, most studies have measured the value of exercise with the whole hand rather than the individual fingers.

The hypothesis of this study is that specific hand exercise that targets the specific individual finger with this certain device incorporated in a home exercise program would have beneficial effects for those with hand OA to improve grip strength, hand function, and joint pain.

The purpose of the study was to determine if individual finger hand exercises using the ViEx™ exercise hand device improves grip strength, hand function, and joint pain in subjects 65 and older who have hand OA.

Methods

A clinical study of 20 participants was conducted to evaluate the daily use of the ViEx™ device for adding to knowledge and treatment of hand OA over the age of 65. The study was conducted every day during a four-week time frame.

Recruitment

Participants were identified through a recruitment process, where initial contact occurred directly by interviewing interested individuals over 65 living in their own homes, and with directors or nurses in charge of residents' care in three senior living centers. Following initial contact, open verbal invitations and flyers were provided to any interested individuals to attend a presentation where the study criteria was specifically outlined and the study parameters were explained in specific detail. The presentations were conducted in three community centers (two in a large city, and one in a small town), two churches (one in a large city and one in a small town), four assisted living homes (two in a metropolitan area, one in a suburb, and one in a rural small town), three nursing homes (one in a rural small town and one in a large city and one in a suburb), and several (more than 10) individual private homes.

No financial benefit was offered to any participant, and all participants volunteered to consider participation in the study. Each potential participant had the capacity to make decisions for themselves and has been able to follow the protocol outlined. Each potential participant was screened for inclusion.

Inclusion Criteria

The inclusion criteria were 65 years and older and self-reported physician diagnosed OA of the hands. Exclusion criteria included any of the following which occurred in the 30 days immediately prior to the study: trigger finger, new medication, formal occupational or physical therapy for the hands, or other hand exercises outside of formal therapy verified by nurses or medical records. The exclusion criteria also included any injections or surgeries of the hand within the past six weeks prior to participating in the study. Twenty-three participants met these criteria. Twenty completed the entire study; three dropped out. Each participant completed a detailed health questionnaire of their past and present health conditions, physical and occupational therapy, and medications. There were 14 females and 7 males with the age range of 68-90 years, the median age range was 81-85 years, and the mean age was 81 years.

Presentation of Study to Participants

The presentations reviewed the study protocol, the eligibility criteria (discussed below), the schedule of exercises and procedures required every day for the length of the study, and the information that will be gathered about the participants. The participants were provided with copies of the specific criteria, the informed consent form, the contact information, the QuickDASH Outcome Measure and Initial Questionnaire,[14,15] Written Daily Exercise Program and expectations for each participant to log their symptoms, a Quick Reference Guide and Pictures of Exercises, Daily Journal Sheets with the Wong-Baker FACES Pain Rating Scale[18] to complete before and after exercises each day of the study.

All participants were given a ViEx™ device and the exercise program was explained and demonstrated to each participant as a group and on an individual basis. Participants could ask

any questions about the study protocol, the ViEx™, exercises or anything else involving the risks, benefits or side effects. The participants all agreed to use the ViEx™ everyday for four weeks and complete the exercises involving both hands and all 10 fingers, and by completing Daily Journal Sheets and the Wong-Baker Pain Rating Scale before and after exercising every day.

Prior to the start of the study, the exercises designed for the ViEx™ were reviewed to assess the exercises as appropriate to use with the elderly hand OA population by two occupational therapists, an orthopedic surgeon, and a sports medicine physician. The purpose of the study was to determine if the specific hand exercises using the ViEx™ hand exercise device would improve grip strength, hand function, and joint pain in participants 65 and older with hand OA.

On visit one, the first day of the study, prior to any exercises, each participant completed grip strength measures and completed the QuickDASH Outcome Measure Questionnaire.[14,15] The average of the three trials for each hand was used as the grip strength measure.[16,17] The QuickDASH is a valid measure of physical function and symptoms in people with musculoskeletal disorders of the upper limb.

Consent

All participants had the capacity to consent and consented by written consent. The study protocol was approved by the Scientific Review Committee (SRC) for the Minnesota Academy of Science.

Exercise details

The exercise program consisted of using each finger to press the string down to the foundation, holding for one second counted as "one mississippi." There were ten repetitions with each finger and, after finishing the repetitions on the first string, moved successively to the fourth string. As the participant continued from the first to the last string (E string being the easiest string to depress, followed by the A, D, and G), each string's tension and width increased, thereby increasing difficulty. To exercise the thumb, the device was turned so that the thickest string was facing the person, and the string was pressed to the wood with the thumb the same number of repetitions, increasing difficulty by moving from the part of the string with the least tension to the part of the string with the most tension. These areas were clearly defined on the device for each subject. This was repeated with both the right and left hands. Using the device, each subject performed the finger exercise in a specified 2.5 centimeter-long area, 12.5 cm away from the bridge that was referred to as the "exercise lane" to maintain consistency.

Check-ins & Final Data Collection

Each participant was visited weekly by a study author to the completion of the fourth visit. Each week, the participants were personally contacted via phone, email and personal visits to check in and answer any questions and discuss the home exercise program (Visits 1, 2, 3, 4).

Following the completion of the fourth and final visit, each of the same outcome measures were completed, grip strength, QuickDASH and all home exercise programs with the daily journals and pain scales were gathered.

Statistics

Statistical tests were completed on the data. As the data are normally distributed and continuous in nature, a paired t-test was run to determine the difference in the mean values. To report the effect of an intervention on the QuickDASH, which was used to measure hand function, the effect size was reported with Cohen's d to standardize mean differences to further analyze the relative effects of two different interventions.

Results

Participants

16 of the participants were living in their own personal residences, and 4 were in assisted living senior community centers during the study. 23 participants enrolled, but two dropped out after three days (did not want to commit to daily exercises), and one dropped out after two weeks due to physical illness. 20 participants completed the entire four weeks, and the statistics were run on data from only those 20 participants.

Grip Strength

The percent improvement for grip strength, hand function and joint pain was calculated from the first visit to the fourth visit of the study. Grip strength change was calculated as percent of improvement (see figure 1) between the initial and final hand strength measures. Overall, 95% of subjects improved their grip strength, with the median for the overall grip strength improvement of 19.5% (minimum of the data points demonstrated a 4.2% improvement, while the maximum of the data points demonstrated a 73.3% improvement). The average percent improvement for grip strength was 28%. The output for paired t-test for grip strength for both left and right hand shows that the difference between the means for the left hand was 4.59 (2.74)

and the means were significantly lower at the final evaluation than they were initially.

t(df=19)=7.47, p<.001

Functional Measure: QuickDASH

The difference between the initial and final QuickDASH for all subjects was calculated as the percent improvement, After the intervention, 95% of the subjects improved their QuickDASH scores. The median for reduction of upper limb disability was 35.3% (ranging from an increase in disability of 26.7% to a reduction of disability of 85.5%). The average percent improvement for upper limb function was 48%. According to the paired t-test analysis, (table 2), the mean difference was 15.9 (14.2) and the mean of the QuickDASH scores were significantly lower at the final evaluation than they were initially (t(df=19)=5.02, p<.001).

Pain Rating Scale

Each participant completed the Wong-Baker Faces Pain Rating Scale every day for four weeks, or 28 days. The level of pain was averaged for the first three days of the study and then averaged for the last three days of the study. Hand pain improved in 70% of the participants. The median for the Wong-Baker pain rating scale resulted in a 50% improvement. The mode demonstrated a 100% improvement (the maximum was 100% improvement, while the minimum was a 33% decline). In comparison to the other outcome measures of the study, the least amount of subjects improved on the Wong-Baker Pain Rating Scale, yet it had the highest median . The average percent improvement for hand pain was 48%.

In order to normalize the strength of income of intervention, COhen's d was calculated. The formula for the paired samples (table 2) was Cohen's d=Mdiff/[(SD1+SD2)/2] (Right: 0.83 Left: 0.55). With .55 considered a medium effect and .83 considered a large effect, these

calculations support this evidence, although lacking a comparison group, has a strong effect on the outcome. The median pain values were statistically significantly lower at days 26-28 of the study. $Z= -3.73$, $p<.001$ (see table 1).

The difference between the means for the right hand was 8.07 (8.47) and the means were significantly lower at the final evaluation than they were initially (see table 1). $t(df=19)=4.26$, $p<.001$

Discussion

In this study, 70% of the subjects improved on joint pain, 95% of the subjects improved on hand function, and 95% of the subjects improved on overall grip strength after the four week exercise program.

The study was designed to assess the overall value of daily hand exercises in the population of those diagnosed with hand OA, specifically using the ViEx™ hand device as a rehabilitative tool. While this study was focused on the ViEx™, the study ultimately evaluated the value of daily exercises. Each participant's change in grip strength, hand function, and joint pain was measured and the overall change in these outcomes was assessed between the initial and final visits. The participants were individually measured without comparison among participants, decreasing the overall variability of the results. There appears to be a large effect of the intervention on function due to the statistical tests run (table 1).

The null hypothesis that the median pain values pre and post exercises were not different can be rejected. Our findings suggest that the change in grip strength, upper limb and hand function, and pain after the ViEx™ exercise program is significant and clinically meaningful. The DASH scores improved more than what is required for a minimally clinically important

difference (MCID). There was a mean change of 15.9, exceeding the MCID of 9-11.3 [15] To ensure precision of the data, the same methods and materials for every subject were used. Variation was kept to a minimum by the same instructor, measurement with the same dynamometer, and used the same questionnaire, and home exercise program and daily journal, and exercise tool, the ViEx™ hand exercise devices, at the initial visit and the last visit.

The limitations of this study are inherent to a small study of this design. This was not a controlled or randomized study; however, it adds to the sparse evidence for an activity or occupation-based exercise program for the population of those with hand OA. The limitation of memory recall was reduced by educating the participants to record their responses for exercises and pain report daily, but it is not possible to know that these were truly completed, except by the person's self-report. Human error is a potential problem in these types of rehabilitation and therapy studies. Each person has their own perception of pain and some participants who have had arthritis longer than others may not remember what it was like to not have any pain or difficulty performing certain activities. These factors could affect pain or functional outcomes in a study such as this, although the fact that each person was measured against themselves decreased the variability of the study.

Another limitation was the small size. Having a larger sample size would have been more representative of the diagnostic group. However, this study aligns with other studies of this population. Also, this was a four-week study, demonstrating that this type of exercise is helpful, but it is not known over a longer amount of time. A study of 20 subjects with the specified criteria aligns with other occupational therapy studies of hand OA. Scientific studies testing exercise devices or programs on hand OA subjects utilized 19 to 26 patients that fit specified

criteria.[7,19] Nine scientific studies reviewed in science journals used 20 subjects or less when testing treatments or exercise programs for hand OA . [7,20]

Multiple scientific studies of exercise programs for hand OA have a duration of one to four weeks in studies with different methods of intervention, with 44 studies that lasted four weeks or less, and testing hand OA patients on different methods of intervention. [6,7,12,21] There are more four week studies than six-week studies that examine hand OA.[21] This study of 20 participants with hand OA obtained data which demonstrated improvement in pain reduction, grip strength and reduced disability with hand exercises which specifically used a novel exercise device. The ViEx™ may significantly benefit those with hand OA by increasing grip strength, improving hand function, and reducing joint pain.

Conclusion

Daily specific hand exercises with a focus on exercising the fingers with graduated force using a specific exercise hand device demonstrates a significant benefit for persons who have hand OA in grip strength, hand function, and joint pain decrease. The results demonstrated 95% of the subjects studied showed improvement in grip strength, 95% of the subjects showed improvement in upper extremity function, and 70% of the subjects showed improvement in joint pain after participating in hand exercises using the device. Further study of specific hand exercises are warranted for the hand OA population; it is still unknown which is of greater value: gripping or specific hand position exercises. Further research using the ViEx™ is recommended for specific individual finger exercises that target individual finger flexion. It may be advantageous to research the use of specific finger exercise with a device such as this for people with other debilitating hand conditions such as stroke, traumatic hand injuries, or those with

rheumatoid arthritis. Further research is additionally needed to test the results of this device in a control group with with no treatment or another more conventional hand therapy approach.

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Table 1. Demographic Characteristics of Participants (n =20)[a]

Characteristics	n	(%)
Gender		
Male	6	(30%)
Female	14	(70%)
Hand Dominance		
Right	14	(70%)
Left	6	(30%)
Ambidextrous	0	(0%)
Ethnicity		
White	17	(85%)
African-American	0 (0%)	
Hispanic	2	(10%)
Pacific-Islander	0 (0%)	
Other	1 (5%)	

Other Variables	M	SD	range
Age (years)	81.4	6.7	68-90
Years living with hand OA	13.2	12.7	1-50

[a]*Note.* n = number of participants

Table 2. ***Within Subjects Comparison (n=20): Descriptive Statistics, Inferential Statistics, and Cohen's d Effect Sizes***[a]

	Pre ViEx		Post ViEx		Difference			
Outcome Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*Test Stat.*	*Effect Size*
QuickDASH	37.4	21.3	21.5	16.5	-15.9	14.2	-5.02**	-0.8
Pain	2.7	1.8	1.2	1.2	-1.5	1.5	-3.73**	-0.8
Grip (Right hand)	17.0	10.3	25.1	9.1	8.1	8.5	7.47**	0.8
Grip (Left hand)	20.5	7.9	25.1	8.8	4.6	2.7	4.26**	0.6

[a]*Note.* **p<.001; QuickDASH = The Short Version of the Disabilities of the Hand and Shoulder Questionnaire; Pain was measured as per the Wong-Baker "Faces" Pain Scale; Grip was measured as per the Jamar Grip Dynamometer and reported in Kilograms; Measures of central tendency were reported as means for continuous (QuickDASH and Grip) and medians for ordinal (Pain) data. Pre and post intervention differences were tested with a paired T-Test for continuous and Wilcoxon Signed Rank Test for Ordinal data. Effect sizes for continuous data were reported as Cohen's *d* or [(Mean Difference/SD) * √2], and Pearson Correlation Coefficients for ordinal or [r=Z/√(n)].

Figure 1. Percent Improvement in Grip Strength

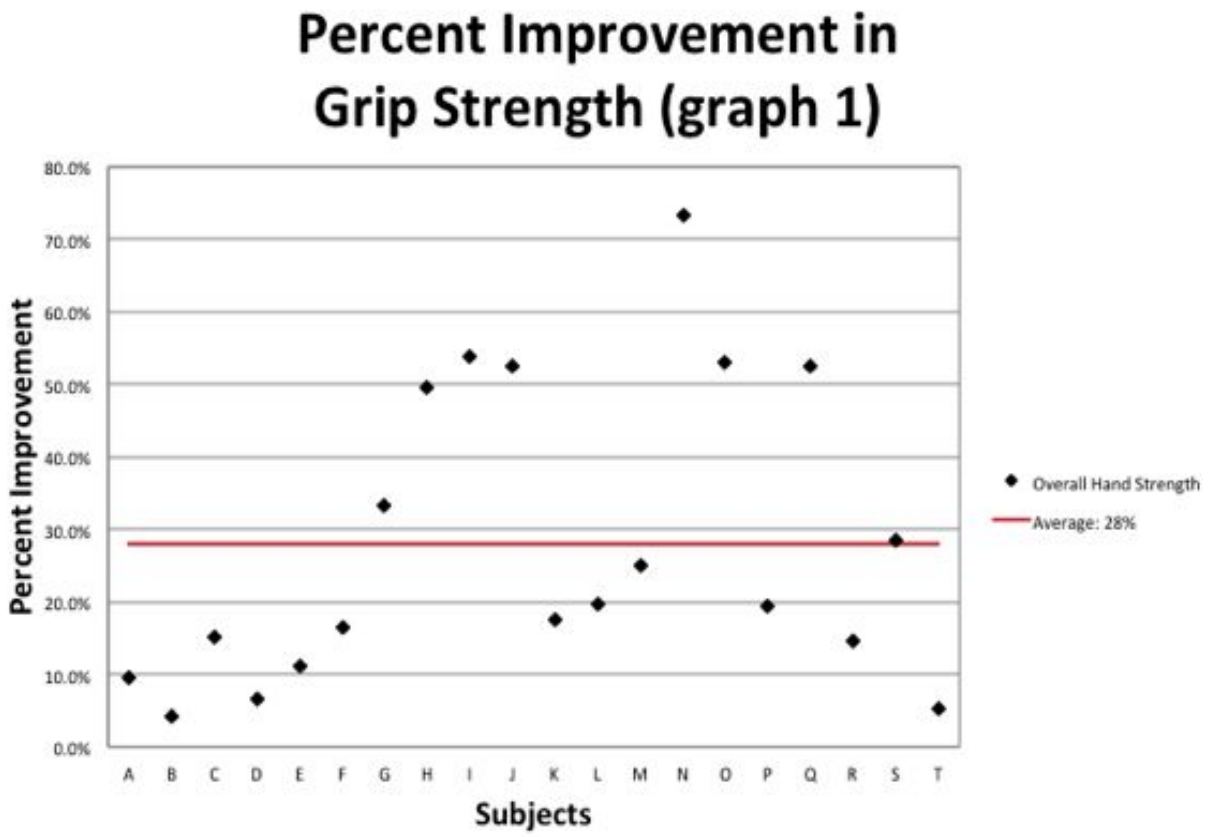

Figure 2. Percent Improvement in hand function

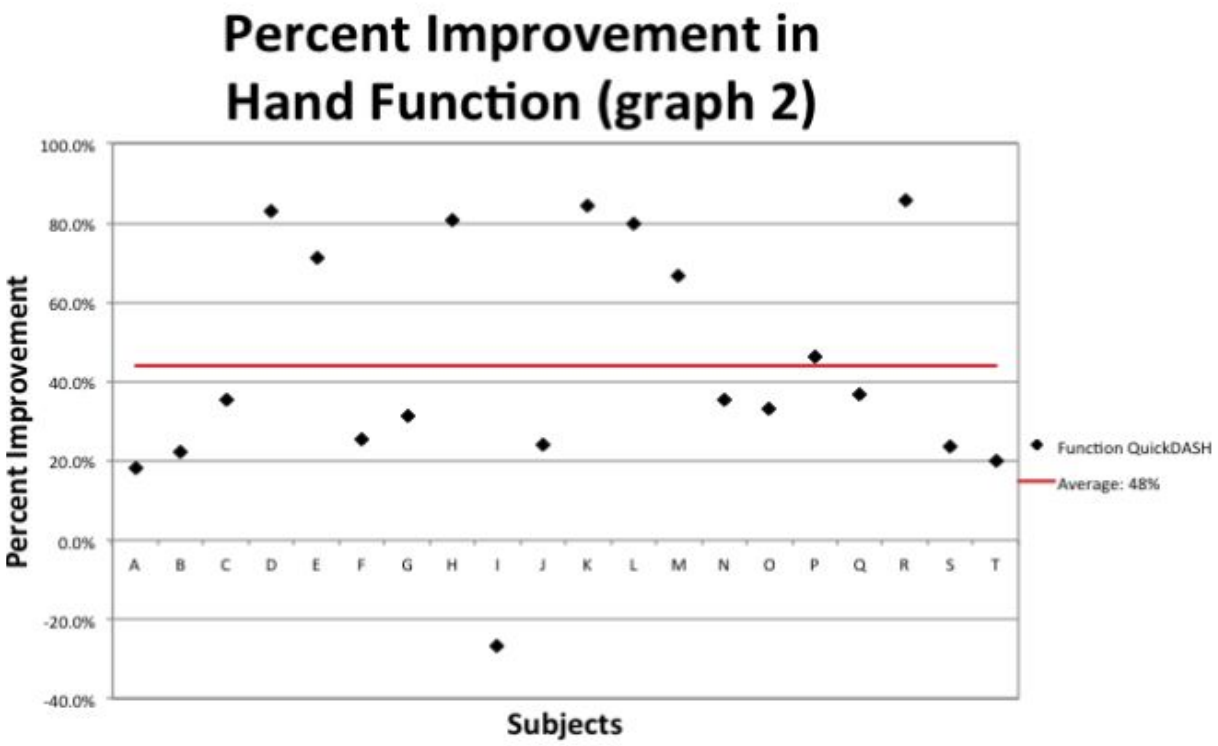

Figure 3: Percent Improvement in Joint Pain