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Clinical effects of proprioceptive thumb exercise for individuals with carpometacarpal joint osteoarthritis: A randomized controlled trial

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ABSTRACT

Study Design: Randomized Control Trial.
Introduction: Thumb CMC joint OA is a common diagnosis. Currently there is no evidence available to under if proprioceptive neuromuscular training is an effective intervention for this population.
Purpose of the study: To establish the effectiveness of a proprioceptive training program as a complementary therapy for patients with thumb CMC joint OA.
Methods: Standard conservative thumb CMC joint OA treatments were received by both the control (n = 26) and experimental groups (n = 26) for a period of 12 weeks. The experimental group received a proprioceptive training program during the same intervention period. Outcome measures included severity of pain with activity according to the numerical rating scale (NRS), QuickDASH, Canadian Occupational Performance Measure (COPM), and proprioception via joint position sense (JPS).
Results: Fifty-two females participated in the study. Both the experimental and control group made both clinically and statistically significant changes in the mean VAS and COPM scores over time. Only the experimental group achieved a statistically and clinically significant change in JPS error score over time.
Discussion: Experimental group achieved a statistically significant change in JPS over time in concordance with previous investigations. Changes in pain scores differed from prior investigations and the between-group comparison was not statistically significant. Changes in the Quick DASH was similar to previous findings.
Conclusion: Proprioceptive training in addition to a traditional rehabilitation program decreased error scores on the joint position sense test.

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Introduction

Thumb carpometacarpal joint (CMCJ) osteoarthritis (OA) is a common diagnosis, affecting 7% of men and 15% of women and is most often seen in postmenopausal women.[1] The symptoms of this diagnosis are progressive over time.[2] The most common reported symptoms include thumb pain at rest and/or during activity, decreased pinch strength, decreased thumb motion, and limitations in functional performance.[2] Pain relief and restoration of function are the primary objectives of rehabilitation.[3-6] Recommended evidence-based interventions for thumb CMCJ OA include a multifaceted approach based on thumb immobilization or support, educational programs, physical interventions, therapeutic exercise programs and manual therapy for reducing pain and improving function.[3-6]

Proprioception is described as the perception of position, motion, and force generated by the body.[7] Proprioceptive signals from mechanoreceptors of the joints, muscles, tendons, and skin

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are essential for the intact neural control of movement. The proprioceptive training approach has evolved over the last decade. Subcategories of kinesthesia, awareness of passive or active joint movement, joint position sense (JPS), reproduction of joint angles actively or passively along with the ability to detect vibrations, level of force produced, and changes in limb or joint velocity have emerged.[8,9] The feedback from these various sensory components arises from the peripheral nervous system (PNS), and feed information to our central nervous system (CNS).[10,11] This occurs at the level of the spinal cord (reflexive) and signals are sent to the cerebral cortex for higher processing.[10,11]

The role of proprioception training is not well described in context to the thumb CMC joint; however, the importance of functional thumb motion and pinch strength in everyday activities is clearly defined and understood. Individuals with osteoarthritis of the thumb CMC joint often present with poor neuromuscular capacity, and proprioceptive deficits.[12] Cadaveric studies of the thumb CMC joint have suggested that ligament innervation may correlate with neuromuscular and proprioceptive changes in CMCJ OA,[13] and previous studies suggest the importance of innervation and proprioception in the stability of the thumb.[14-16] In addition, previous studies of the effects of proprioceptive exercises in knee, ankle or shoulder osteoarthritis provide the foundation for the use of proprioceptive interventions in thumb OA.[17-21]

Joint position sense (JPS) is often measured through active joint position sense (AJPS) and passive joint position sense (PJPS). JPS determines the ability for a person to perceive a presented joint angle and then, after the limb has been moved, to reproduce the same joint angle actively or passively.[22]

Poor proprioception at a joint may result in the increased likelihood of an injury.[23] The reason for proprioception impairments is not completely understood currently. A decreased sense of proprioception can be caused by localized tissue damage, the presence of edema, or competitive nociceptive inputs (presence of pain).[7] Proprioception can also be affected by age.[24,25] Thumb CMCJ OA is found to primarily affect individuals over the age of 65.[4] Proprioception loss increases as we age due to a combination of natural age-related changes to the nerves, joints, and muscles and can be considered contributory factors in the degenerative pathology of thumb CMCJ OA[26]. Therefore, the proprioceptive approach should be considered for addressing the progressive clinical symptoms of this disease process. Although the causality remains unknown, decreased proprioceptive function as measured using the joint- position reproduction test, is associated with the presence of OA in the CMC joint.[12] There is high quality evidence that hand therapy treatment can improve pain and function for individuals with thumb CMCJ OA[27,28] and prior investigations have demonstrated that proprioceptive training improves symptoms in individuals with other types of OA.[29] Despite the recent growing body of evidence regarding the usefulness of thumb proprioception,[27-29] a specific exercise protocol has not been described. High level evidence regarding the role of proprioception in CMCJ OA and the potential role of its training for disease prevention or treatment remains unclear.

More evidence is needed on the effects of proprioceptive neuromuscular facilitation training for individuals with symptomatic thumb CMCJ OA to determine the most effective intervention. Considering the positive effects of the proprioceptive approach in other joints,[17-21] we hypothesize that proprioceptive training for persons with thumb CMC OA may reduce pain intensity and improve JPS, hand function, and occupational performance. The main purpose of this investigation is to study the effectiveness of a proprioceptive training program as an adjunct therapy to traditional treatment for patients with thumb CMCJ OA relative to traditional treatment alone.

Material and methods

Study design

This was a randomized control trial. Patients with thumb CMCJ OA were recruited from December 2019 through July 2020 and were randomly allocated into 2 groups of 26 individuals by an independent statistician who designed the random assignment system.

Participants

Participation in the study was voluntary. Patients were included if they satisfied the following inclusion criteria; over 18 years of age with a diagnosis of grade I, II or III thumb CMCJ OA in their dominant hand according to the Eaton Classification Stage,[30] a minimum pain rating of 4/10 on the Numerical Rating Scale (NRS) during activities of daily living (ADLs) at the time of the initial evaluation, and the ability to read and understand the patient information sheets and exercises. Patients were excluded from participation if they had a neurological disorder affecting the upper limb, received specific treatment for hand or thumb pain in the same limb in the last 6 months including an intra-articular joint injection to the wrist, fingers, or thumb, fracture or significant hand injury, previous surgery to the wrist or hand, or had hand or finger tenosynovitis and/or Dupuytren's disease. We also excluded patients with cognitive impairments who were not able to understand the informed consent and/or exercise program. To reduce known proprioceptive or JPS influences, participants were also excluded if they presented with a fixed thumb adduction contracture or blindness. All participants were provided with written informed consent in accordance with guidelines approved by the local ethics committee.

This study was approved by the regional ethics committee. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. The participants were informed of the study objectives and the right to withdraw from the study at any time. All patients gave their written informed consent before inclusion in this trial.

Participants recruitment and group-allocation

All participants were recruited from a local university hospital and a hand rehabilitation center where they were seeking hand therapy treatment for symptoms related to thumb CMCJ OA. Fifty-two patients were randomly assigned to 2 equal groups of 26 through block randomization by an independent statistician who was responsible for the individual allocations. The main investigator, who is a hand therapist, administered the appropriate intervention. Eligible participants who were referred to hand therapy by a hand surgeon for thumb pain and CMCJ OA of the thumb were invited to participate at the initial hand therapy consultation. Interested patients received an information letter and a follow up phone call by the researcher 3 days later to check their willingness to participate. The experienced assessor who was blinded to the treatment allocation, collected basic demographic data, and conducted all clinical measurements at baseline, four weeks, and 12 weeks post-treatment.

Outcome Measures

Proprioception was the primary outcome. In this study, proprioception was assessed using JPS testing. Proprioception using ac-

tive JPS has been utilized in studies to establish a correlation between therapy intervention and proprioception[31,32] and has been used to assess conscious proprioception in UE rehabilitation.[33,34] Thumb JPS testing appears to have sufficient validity in differentiating between individuals with thumb OA compared to individuals with healthy thumbs.[12] Previous studies evaluated thumb proprioception by using a joint-position reproduction test and compared the reposition error (RE) between the groups.[12] Thumb JPS testing has been identified as a clinically meaningful measure for assessing conscious sensory motor impairment and explaining functional disability levels for patients with CMCJ OA.[35,36]

A standardized protocol[35] for JPS testing of the thumb CMC joint was followed for this study. The target position of 30° of thumb CMC joint abduction was selected. The joint angle was measured using a standard clear plastic goniometer.[37,38] The fulcrum of the goniometer was placed directly over the intersection of the first and second metacarpals. The stationary arm of the goniometer was aligned with the midline of the second metacarpal, and the moving arm was aligned with the midline of the first metacarpal.

Secondary outcome measures included pain intensity, hand function and occupational performance. The severity of pain with activity was measured according to the NRS. The NRS scale is a unidimensional measure of pain intensity that has been widely used in diverse adult populations, including those with rheumatic diseases.[39] The NRS is a reliable instrument[40,41] with demonstrated sensitivity to changes in pain in patients with chronic inflammatory or degenerative pain.[42]

The shortened form of the Disability of the Arm, Shoulder, and Hand Questionnaire (Quick DASH) was used to measure upper extremity function.[43] This tool consists of 11 items and a total score ranging from 0 to 100 where 0 indicates no limitation and 100 suggests full disability. Eight questions inquire about the patient's ability to perform certain daily activities.[44] The Quick DASH is as effective as the full DASH in detecting meaningful change or "responsiveness" in this patient population.[45] The construct validity and the interpretability of the Quick DASH in the assessment of rheumatoid arthritis (RA) hand disability has been previously established.[46,47] Patient's occupational performance was measured with the Canadian Occupational Performance Measure (COPM). The COPM enables subjects to identify goals for hand therapy and engage in a subject-specific therapeutic process. It has been established that the COPM has good convergent validity and responsiveness for evaluating the relationship between patient self-perception and satisfaction for patients with thumb CMCJ OA.[48]

No practice trials were performed by the participants before testing. Participants were seated at a table with the arm resting on the table in a neutral position and elbow at 90°. The patient is asked to close their eyes to carry out the test. The therapist moves the patient's thumb passively to the 30-degree abduction position. The goniometer was removed, and the patient was asked to hold the position for 3 seconds. The therapist then asked the patient to perform full thumb adduction and then return to the initial position (30° CMC abduction). Once the participant confirmed the position, a second measurement was taken. The difference between the target angle and the reproduced angle was used as the JPS deficit criterion value. The greater the angular difference, the greater the JPS deficit. If no differences were measured between the initial position and the final position a zero value was assigned. Positive or negative values were assigned for angular differences greater or lesser than the target angle. For data analysis, the mean value of two measurements was used. Evaluations were repeated at baseline, 4 weeks, and 12 weeks during scheduled therapy visits and were completed prior to any exercises performed in the clinic.

Fig. 1. Flow of Participants.

Intervention

All treatment was provided by a hand therapist with 22 years of experience in clinical practice. The experimental and the control groups received the same instructions for the exercise program during their 4 weeks of skilled therapy treatment. The main investigator performed therapy treatment face to face twice a week for the first month and instructed the participants to perform the same daily home exercise program until week 12 (grouped in 3 sets of 10 repetitions) in the absence of pain. If the patient experienced pain, the number of repetitions dropped to 8, 6, and so on until they were able to perform the exercise correctly without pain. The program was monitored through a self-reported record sheet that they delivered weekly to the therapist and if necessary, video conferences were used to clarify any questions or concerns participants had. Exercises consisted of active-resistive exercises for the first dorsal interosseous (FDI) muscle, manual distraction of the CMC joint and relaxation of the adductor thumb muscle. Also, every participant engaged in an education/joint protection program for improved thumb use during ADL's. Due to limitations in therapy attendance caused by COVID-19, some treatment occurred via video conferencing when in person therapy was restricted or not possible.

All participants received a hand-based thumb orthosis that included the thumb MCP joint to use at night and during ADL's as needed if pain was present (Fig. 1). Participants were also encouraged to use the orthosis for the entire 12 weeks of the study. In addition to the routine care provided as above, the experimental group carried out a proprioceptive exercise program divided in three phases of 2 weeks per phase as outlined in Fig. 2. Phase one was the reproduction of active and passive movement which is also known as joint position matching.[49] The patient reproduced previously established thumb movements 3 times with eyes open and was required to reach a target position that was previously

Fig. 2.

marked, Next the patients were required to reproduce the target thumb position previously performed with eyes closed. In this phase there is no resistive movement. In phase 2, patients reproduced the perceived direction of movement of their thumb, but with application of force. For example, holding a stick of wood or a heavier material, the patient is asked to move his finger three times to a target position and then to reproduce the movement with eyes closed. Additionally, to upgrade for the inclusion of force the patient was asked to squeeze a dynamometer to produce a few grams of force previously chosen and then to reproduce the same amount of force with their eyes closed. In a similar fashion this can be accomplished by squeezing a sponge to a prior determined mark or by pressing a marble with the thumb and bringing it to a previously marked point on the index finger.

In the last phase, participants carried out daily activities adapted to each patient which required them to reproduce different movements of the thumb with eyes open and closed. In this phase, the most significant activities for the patient were used and objects of different textures, weights and densities were alternated.

Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22.0 for Windows. Tests included unpaired t-tests and chi-square to determine whether differences in participants' characteristics existed between groups. Independent t-tests were also used to compare the groups at baseline, after 4 weeks of therapy and 8 weeks following discharge from therapy or 12 weeks from baseline. ANOVA analysis was used to determine group outcome score mean changes over time. The statistical significance level was set at $P < 0.05$ (2-tailed). Cohen's d was interpreted using Cohen's interpretation of effect size.[50] Cohen suggested that 0.2 be considered a "small" effect size, 0.5 represents a "medium" effect size, and 0.8 a "large" effect size.[50] Therefore, if 2 groups' means do not differ by 0.2 standard deviations or more, the difference is considered trivial, even if found statistically significant.

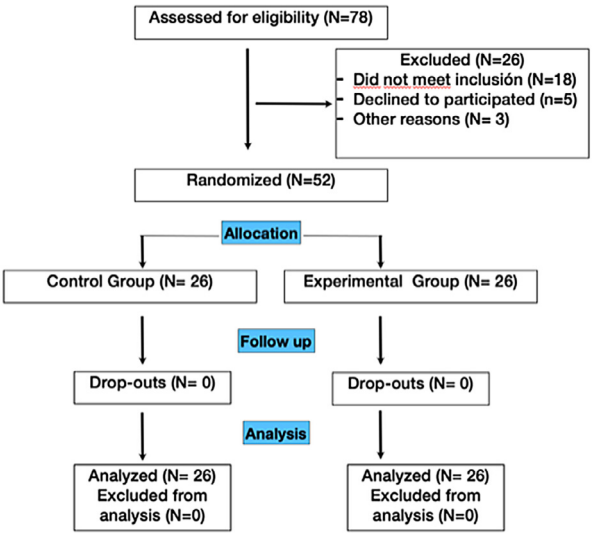

Fig. 3.

Results

The CONSORT flow diagram depicts the progression of phases for this study (Fig. 3). Fifty-two female participants (average age 63 years old) participated in the study (Table 1). Demographic characteristics and baseline outcome measurement scores were compared to determine if the groups were similar at baseline. No statistically significant differences were found between baseline characteristics or baseline outcome measurement scores. At baseline, both the control and the experimental group had an average pain of greater than 7 but less than 8 on the VAS, an average Quick DASH score above 64 and below 65, an average COPM score above 2 and less than 3, and a JPS test average score greater than 9 but less than 11. Four participants in the control group and three in the experimental group completed online sessions due to restrictions related to COVID-19. The total number of online

Table 1
Participant demographics

	Experimental	Control	*P* value
Participants (Engaged in Online sessions)	26 (3)	26(4)	
Gender (Counts(%))			.5[b]
Female	26 (100)	26 (100)	
Male	0 (0)	0 (0)	
Age in Years (M(SD))	63.54 (6.63)	62.7 (7.96)	.24[a]
Work Status (Counts(%))			.68[b]
Retired	13 (50)	16 (61.5)	
Employed	13 (50)	10 (38.5)	
Dominant Hand (Counts(%))			.15[b]
Right	23 (88.5)	25 (96.2)	
Left	3 (11.5)	1 (3.8)	
Affected Hand (Counts(%))			.35[b]
Right	22 (84.6)	23 (88.5)	
Left	4 (15.4)	3 (11.5)	
Number of in-person therapy sessions (M(SD))	8 (0)	8 (0)	
Number of virtual therapy sessions (M(SD))	8 (0)	10 (0)	

[a] Analyzed with unpaired t-test.
[b] Analyzed with chi squared test.

Table 2
Pain outcomes via numerical rating scale at all assessments

	Baseline mean (SD)	4 weeks mean (SD)	12 weeks mean (SD)
Experimental	7.58 (0.94)	5.42 (0.63)	3.35 (0.61)
Control	7.24 (0.83)	6.31 (0.82)	5.34 (0.78)
P value		<.001	<.001
Effect size		1.22	2.84

Table 3
Average quick DASH outcomes at all assessments

	Baseline mean (SD)	4 weeks mean (SD)	12 weeks mean (SD)
Experimental	64.96 (6.03)	52.96 (6.81)	38.88 (6.91)
Control	64.46 (6.71)	58.84 (6.74)	50.42 (6.23)
P value		.001	<.001
Effect size		0.87	1.75

Table 4
Average COPM outcomes at all assessments

	Baseline mean (SD)	4 weeks mean (SD)	12 weeks mean (SD)
Experimental	2.28 (0.71)	4.93 (0.65)	6.44 (0.60)
Control	2.51 (0.65)	3.64 (0.64)	5.51 (0.41)
P value		<.001	<.001
Effect size		2.0	1.80

sessions for the control group was 10 while the experimental group had 8.

For JPS, the experimental group measurement was 6.12 degrees (SD 3.91) and control group measurement was 8.58 (SD 3.54) at the 4-week assessment ($t = 2.33$, $P = .012$, effect size = 0.66) and 3.08 (SD 3.37) and 7.5 (SD 3.47) at the 12-week assessment ($t = 4.57$, $P < .001$, effect size = 1.29). The effect size for all outcomes at the 12-week follow-up was considered large in favor of the experimental group (Tables 2-5).

Only the experimental group achieved a statistically significant change in JPS error score over time (Table 5). For the control group, JPS was 9.81 (SD 4.35) at baseline, 8.58 (SD 3.61) at 4 weeks, and 7.5 (SD 3.53) at 12 weeks ($F = 2.33$, $P = 0.10$). For the experimental group, JPS was 10.12 (SD 4.37) at baseline, 6.12 (SD 3.99) at 4 weeks, and 3.08 (SD 3.44) at 12 weeks ($F = 20.71$, $P < .001$).

ANOVA testing revealed that both the experimental and control group made statistically significant changes in the mean NRS, Quick DASH, and COPM scores over time (Tables 2-4). In the control group, the VAS average score improved from 7.24 (SD 0.83) at baseline to 6.31 (SD 0.83) at 4 weeks and 5.34 (SD 0.78) at 12 weeks ($F = 33.85$, $P < .001$). In the experimental group, the NRS average score improved from 7.58 (SD 0.94) at baseline to 5.42 (SD 0.64) at 4 weeks and 3.34 (SD 0.62) at 12 weeks ($F = 204.96$, $P < .001$).

The average Quick DASH score for the control group improved from 64.46 (SD 6.71) at baseline to 58.85 (SD 6.87) at 4 weeks to 50.42 (SD 6.36) at 12 weeks ($F=29.35$, $p<.001$) and 64.96 (SD 6.03) at baseline to 52.96 (SD 6.94) to 39.16 at 12 weeks ($F=95.00$, $p<.001$) for the experimental group.

In addition, the COPM improved from 2.51 (SD 0.65) at baseline to 3.64 (SD 0.64) at 4 weeks to 5.52 (SD 0.42) for the control group ($F = 173.39$, $<.001$) and 2.28 (SD0.71) at baseline to 4.93 (SD 0.65) at 4 weeks to 6.44 (SD 0.60) at 12 weeks for the experimental group ($F = 257.77$, $P < .001$).

Table 5
Average JPS error (degrees) at all assessments

	Baseline mean (SD)	4 weeks mean (SD)	12 weeks mean (SD)
Experimental	10.12 (4.37)	6.12 (3.91)	3.08 (3.37)
Control	9.81 (4.35)	8.58 (3.54)	7.5 (3.47)
P value		.012	<.001
Effect size		0.66	1.29

Independent t-test revealed that at the 4-week discharge from therapy and at the 12-week follow up, there was a statistically significant difference between groups favoring the experimental group for the pain score outcome. At the 4-week assessment, the experimental group had an average NRS score of 5.42 (SD 0.63) versus 6.31 (SD 0.82) for the control group (t = 4.27, $P < .001$, effect size = 1.22). At the 12-week assessment, NRS for the experimental group was 3.35 (SD 0.61) versus 5.34 (SD 0.78) for the control group (t = 10.04, $P < .001$, effect size = 2.84).

At the 4-week assessment, the Quick DASH score for the experimental group was 52.96 (SD 6.81) versus 58.84 (SD 6.74) for the control group (t = 3.07, $P = .001$, effect size = 0.87). At the 12-week assessment the Quick DASH score was 38.88 (SD 6.91) for the experimental group and 50.42 (SD 6.23) for the control group (t = 6.20, $P < .001$, effect size = 1.75).

At the 4-week assessment, the COPM was 4.93 (SD 0.65) for the experimental group versus 3.64 (SD 0.64) for the control group (t = 7.01, $P < .001$, effect size = 2.0) and at the 12-week assessment COPM was 6.44 (SD 0.60) for the experimental group and 5.51 (SD 6.23) for the control group (t = 6.29, $P < .001$, effect size = 1.80).

Clinical significance was evaluated in this study based on the best available evidence for minimally clinically important differences for the included outcome measures. The NRS minimal clinically important difference (MCID) of 1.37 has been determined for a 10-cm pain scale.[51] Based on 1.37 change for clinical significance for pain on the NRS, the experimental group had a clinically significant change in pain at all assessment times. The control group had a clinically significant decrease in pain on the NRS from baseline to the 12-week assessment. The MCID for the Quick DASH has been found to be 15.9.[52] The control group did not have a clinically significant change in Quick DASH score, but the experimental group had a clinically significant improvement in Quick DASH score when baseline is compared to the 12-week assessment time. The authors of the COPM have suggested that a change of 2 is needed for a clinically significant improvement.[53] The experimental group had an overall clinically significant improvement in COPM score from baseline to the 12-week assessment and a clinically significant change from baseline to the 4-week assessment. The control group had a clinically significant improvement in COPM score from baseline to the 12-week assessment. The MCID for the wrist has been determined to be between 4.28 and 7, however, the MCID for the thumb CMC joint has not yet been established.[34] (Table 6)

Table 6
Clinically meaningful changes of all outcomes based on their respective MCID values

	Baseline -4 weeks	Baseline -12 weeks
NRS pain		
Experimental	2.16*	4.24[a]
Control	0.93	1.89[a]
Quick DASH		
Experimental	12.0	25.8*
Control	5.61	14.04
COPM		
Experimental	2.65[a]	4.16[a]
Control	1.13	3.01[a]
JPS[b]		
Experimental	4.0	7.04
Control	1.23	2.31

[a] Clinically significant findings.
[b] Unable to determine clinical significance as there is not an MCID for the thumb CMC joint.
NRS = Pain numerical pain scale, Dash = Disabilities of the Arm, Shoulder and Hand Scale, COMP = Canadian Occupational Performance Measure, JPS = Joint position sense.

Discussion

The present study incorporates therapeutic exercise with neuromuscular components to investigate if joint position sense, pain and/or function improve with a proprioception approach when compared to traditional therapy alone. The effect sizes for all outcomes at the 12-week follow-up were considered large in favor of the experimental group. Only the experimental group achieved a statistically significant change in JPS over time. However, to date, we do not know the effects that JPS may have on long-term functional variables and patient recovery.

Joint position sense is commonly used to evaluate proprioception.[10] There is evidence to support JPS as a clinically meaningful measure of conscious sensorimotor (SM) impairment in individuals with CMCJ OA.[35] Ouegnin and Valdes found that individuals with thumb CMCJ OA had a mean JPS error of 9.86°.[35] This agrees with our mean baseline deficit of 9.97 in both groups. Additionally, another study reported that individuals with CMCJ OA have an odds ratio of 1.9 likelihood of demonstrating JPS errors when the thumb is positioned in 30° of abduction when JPS is tested.[12] Their JPS error was 3.8° for individuals with thumb CMCJ OA which was less than our baseline deficit.[12] The experimental group demonstrated a 65% (6.4°) reduction in JPS error. This compares with the average improvement of 48% reported by the systematic review on the effectiveness of proprioception training.[55] Karagiannopoulos and colleagues[34] investigated sensorimotor impairment and distal radius fractures with the conclusion that JPS and total grip force were the most clinically useful tests for assessing sensorimotor status. It has been recognized that JPS is a vital component of the SM system as it provides the conscious sense of joint position recognition.[7] The MCID for JPS and CMC joint OA has not yet been determined. However, considering the value JPS has demonstrated for distal radius fractures, the findings from the current study reveal that the JPS error score may achieve both a statistically and clinically significant change in the group receiving proprioceptive exercises.

The change in pain scores from this study differed from prior investigations[36] as our effect size for pain reduction was considered large, however the between-group comparison was not statistically significant.[23] The pain score findings from this study should be considered relevant based on other investigations. Jeong et al.[54] examined the effects of a proprioceptive program on pain intensity and consequently found improvement with

stiffness and additional physical function domains and concluded that proprioceptive training enhanced pain relief and physical function during ADLs in people with knee OA. Similarly, a recent systematic review on the effectiveness of proprioception training reported an average improvement of 52% across all outcome measures of function and sensorimotor skill.[55] In regard to clinical significance this study found that pain improved for all subjects in the experimental group at all time points. However, these findings cannot substantiate long term effects or if the effectiveness of the proprioceptive treatment is maintained over time when specific exercises are discontinued. A previous study[56] on distal radius fracture concluded there was high correlation between pain and sensorimotor function, however an unequivocal relationship between proprioceptive training and level of pain cannot be established in our current study. Change in the Quick DASH was found with clinical significance in the experimental group from baseline to the 12 week follow up. This is similar to the findings of a retrospective study that examined the effects of a dynamic stability approach for thumb CMC joint OA and found clinical significance as the change was greater than the MCID for the Quick DASH.[57] In addition, these findings are similar to those of prior studies that found a reduction in pain due to the correlation between function and pain intensity.[57,58] We should consider the possibility that changes on the Quick Dash may be due to the improvement of pain intensity instead of thumb functionality. The Quick Dash is not considered a condition specific questionnaire for thumb CMC joint OA as it is has not yet been validated as being sensitive to change for patients with this diagnosis. A more specific thumb questionnaire that has been validated for use with individuals with thumb CMC OA would be a more appropriate measure, however, a non-specific thumb questionnaire was validated in the country where the study was performed.

Although no high-level evidence has established the best techniques for proprioceptive rehabilitation for thumb CMCJ OA, evidence does suggest that sensorimotor deficits are greater in individuals with CMCJ OA compared to healthy counterparts.[35] Therefore, inclusion of proprioception exercises was found appropriate for individuals with thumb CMCJ OA to better understand the effects proprioception has on this population beyond impairment measures only. For this reason, the current study used several outcome measures including the COPM, a measure of self-perception and occupational performance, which has been recently validated for individuals with thumb CMC joint OA.[23,40] The results of the aforementioned study[36] concur with our study findings, both clinically and statistically significant changes in participant pain and function over time., However, in the current study the COPM score made greater increases from 2.28 at baseline to 6.44 at 12 weeks compared to the findings of Cantero-Tellez et al. study.[36]

The findings of our study suggest that proprioceptive intervention along with traditional treatment may be an effective intervention for improving sensorimotor impairment.

Study limitations

The 12 week follow up time frame is a limitation of this study. A longer follow of 6-12 months would better describe the long-term efficacy of the intervention. The multimodal intervention makes it difficult to determine the exact impact that proprioception training had on the outcomes. Although the sample size in this study is higher than comparative studies evaluating proprioception and the thumb, a sample size calculation was not completed prior to the commencement of the study. Thus, our study may not have been adequately powered to fully estimate the treatment effect of the combined intervention. The Quick DASH is upper extremity specific and not specific to disability for thumb CMC joint OA and therefore may not be sensitive to functional changes with this diagnosis. It may be more appropriate to utilize a diagnosis specific outcome measure such as the Thumb Disability Examination (TDX).[59] Additionally, we also did not collect data regarding home exercise program adherence, so we were unable to determine if one group was more adherent with performance of their home exercise.

Clinical Implications and Conclusion

Reduced proprioception has been implicated in thumb OA.[35,60] Proprioception and neuromuscular control have an important role in motor planning[61] and consequently in thumb adaptation during ADLs. While the current rehabilitative approach favors a dynamic regiment through re-education and strengthening[62] this study supports the consideration of a proprioceptive program for individuals with a diagnosis of thumb CMCJ OA due to its potential benefit on pain, JPS, and function including self-perception of performance and satisfaction with performance.

Future studies on the effect of proprioception training in thumb CMC OA should use a priori power analysis before undertaking the study. Additional studies that use factorial trial designs will help to determine the isolated effects of the individual components of our combined intervention and will allow for an investigation of optimum dosage and frequency of proprioceptive interventions. Additionally, future research should determine the relationship between home exercise adherence and outcomes for patients with thumb CMCJ OA who engage in this proprioception-training program. Further, it would be beneficial for future research to determine the MCID of JPS change. Finally, another area warranted for future study should include how the loss of proprioception impacts pain and functions for individuals with thumb CMC OA.

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