Effect of traditional Chinese Yijinjing exercise on hand dysfunction in rheumatoid arthritis patients: a randomized controlled trial

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Research Article

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Abstract

Background:

Rheumatoid arthritis (RA) patients suffer from hand dysfunction. Exercise has been shown to affect pain, function and quality of life, as recommended by guidelines. Yijinjing is a traditional Chinese exercise that is beneficial to mind-body health. This study aimed to evaluate the efficacy and safety of Yijinjing for preventing hand dysfunction in RA patients.

Methods: This was a single-center, randomized controlled trial (RCT) in which the outcome assessors were blinded. RA participants who met the eligibility criteria (n = 66) were randomly assigned to the exercise (n = 33) or control (n = 33) group. The former underwent professional Yijinjing exercise three times a week for 12 weeks. The latter maintained ordinary activities without intervention. All outcomes, including the Michigan Hand Function Scale (MHQ), handgrip strength, active range of motion (AROM), RA disease activity (DAS28-ESR), Health Assessment Questionnaire Disability Index (HAQ), anxiety and depression mental status, and wrist ultrasound, were obtained at baseline and after 12 weeks.

Results: The MHQs of the exercise group significantly improved

compared with those in the control group at 12 weeks (p<0.05), with improvements in handgrip strength and active joint range of motion (wrist extension, radial deviation, and metacarpophalangeal flexion) (p<0.05). Although the difference was not statistically significant, the ultrasound score of the exercise group did not increase (p>0.05). The morning stiffness duration, DAS28-ESR, ESR, and CRP level were significantly greater in the exercise group than in the control group (p<0.05). For the quality of life, anxiety, and depression scores, both groups presented improvements compared with the baseline group (p<0.05), while the exercise group was clearly better than the control group (p<0.05). Following the 12-week intervention, neither group experienced any adverse events or substantial abnormalities in their vital signs according to ECG.

Conclusion: Yijinjing exercise can improve hand function and enhance handgrip strength and flexibility in RA patients with low disease activity while ameliorating quality of life and alleviating anxiety and depression while safe and not aggravating joint inflammation.

Clinical trial registration: [https://clinicaltrials.gov/study/NCT05527158], Identifier [NCT05527158].

Introduction

Rheumatoid arthritis (RA) is a chronic inflammatory illness characterized by severe disability and swollen, painful, stiff joints that eventually results in distortion and deformity, significantly lowering quality of life[1]. Approximately 0.2%-1% of people across the world suffer from RA, predominantly females[2]. The etiology and pathogenesis of RA have not yet been sufficiently clarified. Pharmacological treatment is the initial selection. Joint dysfunction, especially hand dysfunction, continues to be a focus and challenge in the clinic[3], despite the extensive development and application of biological agents and disease-modifying anti-rheumatic drugs (DMARDs) in recent years, which have drastically ameliorated the disease activity of individuals with RA. According to evidence, 70% of RA patients may experience bone erosion within two years of disease diagnosis[4]. Moreover, up to 90% of RA first affect the wrist and hand, which results in hand dysfunction[5]. As a result, we must pay particular attention to clinical hand dysfunction in patients with RA[6].

Despite active pharmacological treatment, patients do not always maintain sustained disease remission, and functional impairment continues to plague RA patients. As a result, complementary and alternative medicine treatments for RA, such as acupuncture, physical exercise, and arthritic gloves, have gradually been developed and emphasized. In the past several years, reinforcement exercises for inflamed joints or flexion motions against resistance have been questioned due to the fear of injury or excessive deformation of the joints[7]. Currently, active exercise is commonly recognized as safe and effective for treating RA. Professional exercise rehabilitation guidance can alleviate dysfunction and improve quality of life in RA patients[8–9]. More crucially, consistent engagement in exercise received a strong recommendation in the 2022 American College of Rheumatology (ACR) guideline[10]. The value of functional exercise in individuals with RA is emphasized in several recommendations. Exercise treatment has been verified in several meta-analyses to assist RA patients with their pain, somatic function, and quality of life, but it is still unclear what kind, how much, and how often they should take[11–12].

There is comparatively little clinical research aimed at hand function training for individuals with RA. The Strengthening and Stretching for Rheumatoid Arthritis of the Hand Trial (SARAH), an individually designed, progressive exercise program for the hands and arms, was conducted in a British multi-center (n = 17), randomized, double-blind controlled trial[13]. This exercise may reduce hand discomfort and strengthen hand function even if RA patients with acute small muscle atrophy and hand abnormalities[14–15]. It is also helpful in restoring and maintaining hand function in individuals with RA and is beneficial for daily life, work, and mood. More importantly, the potential benefits persisted for up to 12 months[16–17]. A meta-analysis illustrated that exercise might enhance hand function, but it is still unclear whether it can generate medium- and long-term benefits. Due to the varying levels of evidence, it is necessary to carry out further high-quality research to investigate the benefit of exercise treatment on hand function in patients with RA[18].

Yijinjing is a multi-component and psychosomatic traditional Chinese therapy based on traditional Chinese medicine theory that is easy to learn, convenient, high-security, moderate-intensity, and combines static and dynamic movements with non-invasive external physiotherapy[19]. Yi symbolizes change, Jin represents muscles, sinews, bones, and joints, and Jing means methods that integrate the body with mood[20]. As a result, it offers a profitable complementary therapy for ameliorating physical function, regulating emotions, and relieving mental stress[21]. At present, research on Yijinjing has focused primarily on motor and cognitive function in poststroke survivors, as well as on osteoarthritis, ankylosing spondylitis, chronic schizophrenia, and emotional disorders[22–23]. Nevertheless, there are relatively few studies on RA. Previous research has tentatively suggested that three months of Yijinjing exercise can increase the joint range of motion, handgrip strength, and walking distance and ameliorate psychological conditions such as anxiety, depression, and exhaustion[24].

However, this study had a small sample size and did not follow with interest in hand function. Thus, we conducted a randomized controlled trial to fill these gaps, with the main goal of improving hand function. In patients with RA, we hypothesized that Yijinjing intervention would exert a positive impact on hand function or others.

Materials and Methods

Participants

Participants were recruited from the ward and outpatient clinic of the rheumatology department at Guang'anmen Hospital, China Academy of Chinese Medical Sciences, from February 2022 to December 2022. The subjects met the following criteria: (1) met the RA classification criteria updated by the ACR/EULAR in 2010 or the diagnostic criteria established by the American College of Rheumatology (ACR) in 1987; (2) were aged 18–65, regardless of sex; (3) had DAS28 ≤ 3.2; (4) had joint function in grades I to II and X-ray in stages I to II; (5) did not use or maintain a stable dose of DMARDs, biological agents, or hormones within four weeks prior to screening; (6) had swollen or painful wrist joints or finger joints (MCPs, PIPs); (7) all patients were tested for hand dysfunction by a professional rheumatologist; and (8) volunteered to participate and were ready to cooperate to complete this study. The exclusion criteria were as follows: (1) had Yijinjing exercise experience within the last three months; (2) had severe joint deformity (including subluxation and severe ulnar deviation) or joint ankylosis; (3) had other diseases affecting limb function, such as trauma, fractures, infections, tumors, or congenital malformations; (4) had complications such as severe cardiovascular, brain, liver, lung, kidney, or hematopoietic system diseases; (5) had moderate or severe cognitive impairment and were unable to cooperate with the treatment; and (6) were unwilling to join. All patients provided informed consent prior to baseline assessments for eligibility.

Study Design

This was a 12-week single-center randomized controlled trial in parallel that compared the Yijinjing intervention to usual care control. Sixty-six eligible patients were randomly allocated to the Yijinjing group (YJJG) or the control group (CG) at a 1:1 ratio. The persons not involved in participant recruitment generated a random sequence through a random number table for randomization and assignment using sealed envelopes. The outcome assessors were blinded to the allocation. All outcomes were measured at baseline and 12 weeks.

The study protocol, informed consent, and case report forms (CRFs) all met the requirements of the Helsinki Declaration, and the enrollment, intervention, and measurement schedule adhered to SPIRIT's requirements. This trial protocol has been registered in ClinicalTrials (NCT05527158) and approved by the Guang'anmen Hospital Research Ethics Committee, Chinese Academy of Chinese Medical Sciences[2022-002-KY-01].

Sample size

The sample sizes were calculated using improvement on the Michigan Hand Function Scale as the primary outcome. According to previous research[25], the minimal clinically important difference in the MHQ score is 11.0. Therefore, we assumed that the experimental group improved by 11.0 mean compared with the CG group, with a standard deviation of 12.5, an alpha value of 0.05, and a test power of 90%. Considering a 20% shedding rate for follow-up, we eventually enrolled at least 66 participants, 33 individuals in each group. The formula is as follows.

$$N_1 = N_2 = 2\left(\sigma\frac{t_{\alpha/2}+t_{\beta}}{\mu_1-\mu_2}\right)^2$$

Interventions

We advised patients to maintain their regular daily activities but not to initiate any other new exercise. The necessity of physical activity and at-home exercise, daily preventive measures and awareness of the physiology and pathology of RA were emphasized for all participants. All patients sustained standard pharmacological therapy for RA. The control group (CG) received routine joint rehabilitation guidance, such as energy conservation and protection, without additional exercise interventions. The participants in the Yijinjing group (YJJG) underwent interventions three times a week for 12 weeks. Each exercise lasted an hour and consisted of three integral Yijinjing exercises that ended with a five-minute break each. The Yijinjing, compiled by the State Sports General Administration of China and including twelve operational processes, was recommended as the standard intervention (Fig. 1). Professional instructors with at least five years of experience carried out action decomposition teaching before the formal exercise started. During the exercise, we paid attention to the patient's hand function, especially flexion and extension of the wrist and interphalangeal joints. In addition, we concentrated on the center of gravity movement and assisted breathing naturally. The exercise was undertaken in the form of online *Tencent meetings*. The researchers evaluated the attendance of meetings and instructed patients to keep self-exercise report records. As long as the attendance record was > 65% during the three months, the experiment was deemed complete.

Outcome Measurements

Primary outcomes: The Michigan Hand Outcomes Questionnaire (MHQ) consists of 37 questions divided into the following six categories: (1) overall hand function; (2) activities of daily living; (3) work performance; (4) pain; (5) aesthetics; and (6) patient satisfaction with hand function, measured individually for the left and right hands[26]. It is an extensively used hand-specific outcome tool in clinical chronic hand illnesses with strong reliability and validity[27].

Secondary outcomes:

Handgrip strength and flexibility: Handgrip strength can reflect hand strength. The use of electronic grippers is more sensitive and easier for patients with weaker grip strength[28]. Hence, an electronic gripper was used to assess handgrip strength (kg). The subjects grabbed with the highest possible force while not suffering any pain or discomfort while seated, with their shoulders not twisted, their elbows bent at a 90-degree angle, and their forearms in a neutral

position[29]. The test was carried out three times with an interval of 15 seconds, and the final result was set as the average value. One measurement was acceptable for those with visibly painful joints[30].

The active range of motion (AROM) reflects hand flexibility. Reduced hand ROM is closely related to patient functional disability[31]. We used a protractor to judge the AROM. First, we determined the joint and fixed axis and then rotated the moving axis relative to the zero-degree position to calculate the wrist flexion, extension, ulnar deviation, radial deviation, MCP flexion, and PIP flexion angles. The subjects must actively use their muscular power to move.

RA disease activity

Morning stiffness duration is an internationally recognized marker of inflammatory activity in RA patients. The duration (in minutes) of morning stiffness was gauged by the patients' self-reports. The visual analogue scale (VAS) quantitatively indicated the pain intensity in patients with RA, with 0 signifying "no pain" and 10 signifying "the worst intolerable agony"[32]. We evaluated the number of swollen, painful, and deformed joints among the 28 peripheral joints on the DAS28. Rheumatoid factor (RF), the erythrocyte sedimentation rate (ESR), and C-reactive protein (CRP) were detected and recorded. Thus, we assessed RA disease activity using the internationally recognized DAS28-ESR.

Quality of Life

As advised by the American College of Rheumatology, the Health Assessment Questionnaire (HAQ) has been thoroughly validated and measured in most RA trials[33]. The scale contains 20 questions about daily activities such as dressing, brushing, getting up, eating, strolling, maintaining personal hygiene, touching, and holding[34].

Psychological condition: The self-rating depression scale (SDS) was used to measure the severity of depression; higher scores reflect symptom severity[35]. The self-rating anxiety scale (SAS) mainly consists of 20 items and is a validated self-assessment tool for measuring the intensity of anxiety.

Wrist Ultrasonography

Two professionally trained musculoskeletal ultrasonographers, associate chief physicians or above, evaluated the conditions of synovitis, tenosynovitis, and bone erosion on the wrist joint. According to the European League Against Rheumatism-Rheumatology Outcome Measurement (EULAR-OMERACT) score[36], synovitis, tenosynovitis, and bone erosion were graded from the same wrist joint at baseline and 12 weeks.

Safety assessment: Electrocardiograms (ECGs) were performed, along with the individuals' vital signs (blood pressure, respiration, heart rate, and pulse), and adverse reactions were recorded.

Statistical analysis

SPSS 26.0 statistical software was used for data analysis, and $p < 0.05$ was considered to indicate statistical significance. Continuous variables are described as the means ± standard deviations for normally distributed data or medians (25%, 75%) for nonnormally distributed data, while categorical data are expressed as frequencies and percentages. For differences between groups, an independent sample T test (normal, homogeneity of variance) or Wilcoxon Mann—Whitney test (nonnormal, heterogeneity of variance) was used for continuous data, while the chi—square test or Fisher's exact test was used for counting data and grade data. In terms of intragroup comparisons, the paired-sample t test or Wilcoxon Mann—Whitney test (nonnormal) was used for the metric data, while the McNemar test or the McNemar-Bowker test was used for the counting index.

Results

Participants and baseline characteristics

A total of 66 patients with RA who satisfied the inclusion criteria, were willing to participate, signed informed consent, and eventually were allocated to the YJJG and the CG. Six subjects dropped out due to loss to follow-up, and 60 subjects finally completed the entire trial (YJJG: n = 30, CG: n = 30). The entire trial flow diagram is shown in Fig. 2. 95% of the participants were female, and the average ages of the patients in the YJJG and CG were 54.80 ± 8.50 and 51.63 ± 10.63 years, respectively, which is consistent with the prevalence of RA in middle-aged and elderly females. At baseline, they were comparable between the two groups in terms of age, sex, height, weight, MHQ score, handgrip strength, AROM, RA disease activity (DAS28-ESR), ECG, and so on. The DAS28-ESR of both groups was < 3.2, and the disease activity was relatively stable. No significant differences were detected (all $p > 0.05$) (Table 1).

Table 1
Baseline characteristics of participants in the study.

Characteristic	Control Group (n = 30)	Yijinjing Group (n = 30)	*P* value
Age (year)	51.63 ± 10.63	54.80 ± 8.50	0.207
Gender (female/male)	28/2	29/1	1.000
Height (cm)	161.57 ± 5.85	161.82 ± 4.80	0.875
Weight (kg)	59.37 ± 8.81	57.57 ± 7.27	0.392
MHQ score (range 0-100)	49.58 ± 10.48	51.48 ± 8.36	0.442
Handgrip strength (kg, right)	17.89 ± 6.70	19.07 ± 5.96	0.474
Handgrip strength (kg, left)	16.91 ± 6.38	18.91 ± 6.79	0.246
Wrist/finger AROM (°)			
Wrist extension (right)	53.5(41.75,56.25)	53.0(46.25,58.0)	0.773
Wrist extension (left)	54.0(40.0,60.0)	54.0(51.5,60.0)	0.149
Wrist flexion (right)	57.0(36.5,66.0)	57.0(42.0,64.0)	0.982
Wrist flexion (left)	56.0(40.5,64.0)	56.0(46.0,62.5)	0.750
Wrist ulnar deviation (right)	30.0(25.5,35.25)	30.0(23.0,32.0)	0.435
Wrist ulnar deviation (left)	30.0(26.0,36.0)	30.0(23.5,34.0)	0.457
Wrist radial deviation (right)	13.63 ± 5.20	14.20 ± 3.94	0.636
Wrist radial deviation (right)	12.5(10.0,18.0)	14.0(12.0,16.5)	0.317
MCP flexion (right)	80.0(73.0,86.0)	80.0(71.5,84.0)	0.503
MCP flexion (left)	80.0(78.0,84.5)	81.0(78.0,84.0)	0.771
PIP flexion (right)	89.93 ± 10.78	85.67 ± 10.09	0.119
PIP flexion (left)	92.0(87.5,96.5)	90.0(80.0,92.5)	0.150
finger extension (cm, right)	3.0(1.73,4.0)	3.15(3.0,4.0)	0.294
finger extension (cm, left)	3.65(2.08,4.43)	3.8(3.5,4.28)	0.369
Morning stiffness duration (min)	15(10,20)	15(10,30)	0.214
DAS28-ESR (score)	2.97 ± 0.85	2.85 ± 0.82	0.674
ECG abnormal	8 (26.67%)	11 (36.67%)	0.405

The values are expressed as the means ± SDs or medians (25%, 75%). MHQ: Michigan Hand Outcomes Questionnaire; MCP: metacarpophalangeal joint; PIP: proximal interphalangeal joint; DAS28-ESR: disease activity score in 28 joints-erythrocyte sedimentation rate; ECG: electrocardiogram, abnormal but not clinically significant. $p > 0.05$ indicated no significant difference between groups at baseline. MCP/PIP flexion was calculated by means of MCP2-4 and PIP2-4.

Effect of Yijinjing on hand function

Hand function, as measured by the MHQ score, handgrip strength, and AROM, was definitely ameliorated in the Yijinjing exercise group compared with the baseline and control groups after 12 weeks. Compared with those at baseline, not only the MHQ score but also the scores on six subscales, namely, overall hand function, activities of daily living, work performance, pain, aesthetics, and patient satisfaction, were significantly greater ($p < 0.05$). What is more, the YJJG group performed better than the CG group did, with clinical significance ($p < 0.05$). In terms of handgrip strength, both the left and right hands increased by > 1.0 kg, which was a statistically significant improvement compared with baseline ($p < 0.05$), while the control group did not significantly improve handgrip strength ($p > 0.05$). In addition, all the AROM markedly increased by 6–10° in the YJJG ($p < 0.05$), while that in the CG increased by 1–4° compared with that at baseline. Wrist extension, wrist radial deviation, and MCP flexion in the YJJG group were greater than those in the CG ($p < 0.05$), but no significant changes in PIP flexion, wrist ulnar deviation, or left wrist flexion were observed between the two groups ($p > 0.05$). For the wrist ultrasound score, there was a slight decrease in the YJJG score compared with that at baseline, while there was mild aggravation in the CG after 12 weeks of intervention, but no significant difference was found ($p > 0.05$) (Table 2).

Table 2
Effect of Yijinjing on hand function in the study.

Hand function	Baseline		Week 12		Difference from baseline		*P* Value (within-group)		*P* value(between-group)
	CG (n = 30)	YJJG (n = 30)	CG (n = 30)	YJJG (n = 30)	CG (n = 30)	YJJG (n = 30)	CG	YJJG	
MHQ score	49.58 ± 10.48	51.48 ± 8.36	55.04 ± 7.57	65.57 ± 5.86	5.46 ± 5.77	14.09 ± 6.89	<0.001	<0.001	**<0.001**
Handgrip strength-R(kg)	17.89 ± 6.70	19.07 ± 5.96	18.08 ± 6.37	20.26 ± 6.20	0.19 ± 1.02	1.19 ± 1.94	0.323	0.002	**<0.001**
Handgrip strength-L(kg)	16.91 ± 6.38	18.91 ± 6.79	17.16 ± 5.77	20.62 ± 5.93	0.25 ± 1.47	1.71 ± 2.23	0.366	<0.001	**<0.001**
Wrist ultrasonography									
Total score	3(2,5)	3(1,5)	4(2,5)	2(1,4.5)			0.092	0.057	**0.027**
Synovitis grade	1(1,2)	1(1,2)	2(1,3)	1(0,2)	0(0,1)	0(-1,0)	0.334	0.145	0.052
Peritendinitis grade	0(0,0)	0(0,1)	0(0,1)	0(0,1)	0(0,0)	0(-1,0)	0.751	0.238	0.075
Bone erosion grade	2(0,3)	0(0,3)	2(0,3)	0(0,3)	0(0,0)	0(0,0)	0.102	0.890	0.386
Wrist/finger AROM (°)									
Wrist extension -R	53.5(41.75,56.25)	53.0(46.25,58.0)	54.5(39.5,58.5)	62.0(54.75,66.25)			0.002	<0.001	**0.002**
Wrist extension-L	49.63 ± 12.31	54.0(51.5,60.0)	52.20 ± 12.21	65.0(60.0,70.0)			<0.001	<0.001	**<0.001**
Wrist flexion-R	57.0(36.5,66.0)	57.0(42.0,64.0)	59.0(39.75,64.0)	66.0(56.0,70.0)			0.009	<0.001	**0.030**
Wrist flexion-L	56.0(40.5,64.0)	54.0(51.5,60.0)	58.0(41.5,64.5)	62.5(52.0,70.0)			0.002	<0.001	0.071
Wrist radial deviation-R	14.0(8.0,18.0)	14.0(11.5,18.0)	16.0(10.0,18.5)	20.0(18.0,20.0)			<0.001	<0.001	**0.002**
Wrist radial deviation-L	12.5(10.0,18.0)	14.0(12.0,16.5)	14.0(11.5,18.5)	18.0(16.0,20.0)			0.003	<0.001	**0.002**
Wrist ulnar deviation-R	30.0(25.5,35.25)	30.0(23.0,32.0)	30.0(25.5,36.0)	34.0(29.5,38.0)			0.121	<0.001	0.105
Wrist ulnar deviation-L	30.0(26.0,36.0)	28.87 ± 5.84	31.0(26.0,36.0)	32.60 ± 4.21			0.181	<0.001	0.348
MCP flexion-R	79.00 ± 7.56	80.0(71.5,84.0)	81.93 ± 5.34	88.0(85.5,90.0)			0.002	<0.001	**<0.001**
MCP flexion-L	80.40 ± 6.27	81.0(78.0,84.0)	82.53 ± 4.36	88.0(84.0,90.0)			0.002	<0.001	**0.002**
PIP flexion-R	92.0(85.5,98.0)	90.0(78.0,94.0)	94.0(88.0,98.0)	96.0(93.5,98.5)			0.006	<0.001	0.109
PIP flexion-L	92.0(87.5,96.5)	90.0(80.0,92.5)	94.0(87.5,98.5)	96.0(92.0,98.5)			<0.001	<0.001	0.104
finger extension-R(cm)	2.85 ± 1.32	3.15(3.0,4.0)	3.08 ± 1.29	3.9(3.0,4.58)			0.023	<0.001	**0.018**
finger extension-L (cm)	3.65(2.075,4.425)	3.8(3.5,4.28)	3.75(2.25,4.80)	4.5(4.0,4.65)			0.010	<0.001	0.056

The values are expressed as the means ± SDs or medians (25%, 75%). R: right; L: left. $p < 0.05$ indicated a significant difference.

Effect of Yijinjing on RA disease activity

After 12 weeks of Yijinjing exercise, the VAS score, duration of morning stiffness, number of tender joints, number of swollen joints, and DAS28-ESR of the YJJG group were significantly different from those at baseline ($p < 0.05$), while RF, ESR, and CRP did not significantly decrease ($p > 0.05$). No evidence of within-group differences in the CG was found, except for the VAS score and minutes of morning stiffness ($p < 0.05$). Compared with those in the CG, the VAS

score, morning stiffness duration, DAS28-ESR, ESR, and CRP in the YJJG group significantly improved after the intervention ($p < 0.05$). More importantly, the disease activity of the subjects in the YJJG turns into remission (Table 3).

Table 3
Effect of Yijinjing on RA disease activity.

RA disease activity	Baseline		Week 12		*P* Value (within-group)		*P* value(between-group)
	CG (n = 30)	YJJG (n = 30)	CG (n = 30)	YJJG (n = 30)	CG	YJJG	
PGA	30(20,36.25)	30(20,30)	20(10,30)	10(10,11.25)	<0.001	<0.001	**<0.001**
MSD (min)	15(10,20)	15(10,30)	10(8.8,11.3)	5(0,5)	0.003	<0.001	**<0.001**
TJC	1(0,2)	1(0.75,3.0)	0.5(0,2)	0(0,2)	0.069	0.001	0.432
SJC	0(0,0)	0(0,0)	0(0,0)	0(0,0)	0.429	0.025	0.078
RF (umol/L)	97.69(32.54,207.67)	53.7(27.31,143.48)	99.52(37.24,233.97)	62.38(37.2,132.56)	0.884	0.673	0.099
ESR (mm/h)	16.0(11.5,25.0)	13.5(7.0,23.0)	23(14,33)	10(7,18.75)	0.179	0.346	**0.007**
CRP (mg/L)	0.64(0.5,2.01)	0.5(0.5,1.44)	2.57(0.5,4.59)	0.5(0.5,0.5)	0.030	0.463	**<0.001**
DAS28-ESR	2.97 ± 0.85	2.85 ± 0.82	2.83 ± 0.67	2.15 ± 0.83	0.621	0.001	**0.002**

The values are expressed as the means ± SDs or medians (25%, 75%). PGA: Patient's Gobal assessment of disease activity on a VAS 0-100 mm; MSD: Morning stiffness duration; TJC: Tender joint count; SJC: swollen joint count; RF: Rheumatoid factor; ESR: Erythrocyte sedimentation rate; CRP: C-reactive protein; DAS28-ESR: Disease activity score in 28 joints on erythrocyte sedimentation rate. $p < 0.05$ indicated a significant difference.

Effect of Yijinjing on function and mental condition

As for dysfunction in daily activities, we observed HAQ score decline in both groups compared with baseline and superior performance in the YJJG ($p < 0.05$). In terms of mental condition, the differences in anxiety and depression scores between baseline and week 12 were significant ($p < 0.05$). Furthermore, YJJG was as safe as CG without serious adverse events (Table 4).

Table 4
Effect of Yijinjing on function, mental health and safety.

Hand function	Baseline		Week 12		Difference from baseline		*P* Value (within-group)		*P* va gr
	CG (n = 30)	YJJG (n = 30)	CG (n = 30)	YJJG (n = 30)	CG (n = 30)	YJJG (n = 30)	CG	YJJG	
HAQ score	0.13(0,0.75)	0.13(0,0.38)	0.13(0,0.5)	0(0,0)	0(-0.13,0)	-0.13(-0.38,0)	0.003	<0.001	**0.**
SAS score	37.5(30.94,45.31)	39.38(32.5,48.75)	33.75(27.5,38.75)	30.0(27.5,35.31)	-3.75(-7.5, -1.25)	-8.13(-13.75, -3.75)	<0.001	<0.001	**0.**
SDS score	35.0(28.44,44.06)	35.0(,31.25,46.56)	31.25(27.5,40.0)	28.13(26.3,35.3)	-1.88(-5, -0.94)	-6.25(-14.06, -2.5)	<0.001	<0.001	**0.**
Systolic pressure (mmHg)	119.00 ± 5.82	119.20 ± 4.87	116(116,122)	116(115,122)	-	-	-	-	0.
Diastolic pressure(mmHg)	74(72,76)	72(69,76)	74(72,78)	74(72,77)	-	-	-	-	0.
Pulse (counts/min)	72.43 ± 4.17	73.76 ± 6.19	72.22 ± 3.77	72.00 ± 4.97	-	-	-	-	0.
Temperature (°C)	36.2(36.2,36.3)	36.2(36.1,36.3)	36.3(36.2,36.3)	36.2(36.1,36.3)	-	-	-	-	0.
Breath (counts/min)	17(16,18)	16(16,17)	16(16,18)	16(16,18)	-	-	-	-	0.
ECG abnormal(n,%)	8 (26.67%)	11 (36.67%)	9 (30.0%)	13 (43.3%)	-	-	-	-	0.

The values are expressed as the means ± SDs or medians (25%, 75%). HAQ: Health Assessment Questionnaire; SAS: Self-rating Anxiety Scale; SDS: Self-rating Depression Scale; ECG: Electrocardiogram. $p < 0.05$ indicated a significant difference.

Discussion

In 2022, the ACR recommended hand exercises to improve mobility and strength, with low certainty evidence suggesting that mind-body exercise can improve physical function. As far as we know, this is the first randomized controlled trial aimed at examining how Yijinjing affects hand function in patients with rheumatoid arthritis (RA). First of all, in RA patients with low disease activity who underwent 12 weeks of Yijinjing exercise, the hand function score dramatically improved. Second, there was a notable improvement in handgrip strength and active range of motion, showing no progression in inflammation under ultrasound. Third, not the disease activity of YJJG did worsen, but the quality of life, anxiety and depression also gradually ameliorated.

Yijinjing can improve hand function scores in RA patients. Due to successive progressive joint erosion, RA often leads to functional disability, typically resulting in hand dysfunction. The Michigan Hand Outcomes Questionnaire (MHQ) is widely used to evaluate hand function in clinical chronic hand diseases[37]. Dilek Durmu's study[38] showed that MHQ scores moderately correlate with disease activity, in which higher DAS28 scores tended to correlate with lower MHQ scores, indicating worse hand function. Our study revealed that the YJJG and CG had relatively low MHQ scores of approximately 50 points at baseline, especially for overall function, work, aesthetics, and hand satisfaction, which revealed that most patients with low disease activity or remission were not satisfied with their hand function even without moderate or severe joint pain. The MHQ total and each subscale score in YJJG improved more significantly than CG compared with baseline, indicating that Yijinjing rehabilitation exercise for 12 weeks could effectively ameliorate the satisfaction of RA patients with their hand function. This finding was consistent with previous studies[39] showing that strengthening and stretching for rheumatoid arthritis of the hand (SARAH) for 12 weeks can improve the MHQ in RA patients. The Yijinjing exercise is highly similar to the SARAH program. For example, the first posture *Wei tuo xian chu* requires putting your hands together before your chest and maintaining as far as possible 90° wrist extension to exercise the wrist fully. Our study preliminarily showed that Yijinjing exercise can effectively improve MHQ hand function in RA patients. In the future, further multi-center RCTs should be carried out, and a positive control, such as SARAH, could be set up to obtain more evidence.

Yijinjing can enhance handgrip strength and flexibility in RA patients. According to previous studies, handgrip strength is critical for assessing hand function and can predict disability and joint impairment in RA[40–41]. The active range of motion (ROM) reflects hand flexibility quantitatively[42]. High disease activity, more pain, severe dysfunction, hand disability, and bone erosion in RA patients have been associated with low grip strength[43] and worse ROM[44]. For healthy people, the grip strength in a neutral position in the dominant hand was 29.1 kg, with a wrist flexion of 79.7°, a wrist extension of 74.4°, a pronation position ulnar deviation of 32.8° and a radial deviation of 21.1° in Stacy Fan's study[45]. However, for RAs with high disease activity, the grip strength was 11.4 kg[46], with wrist flexion of 38.7°, wrist extension of 35.2°, ulnar deviation of 29.7° and radial deviation of 13.1°[47]. In terms of our study, we included 95% RA with low disease activity. The grip strength at baseline was less than 20 kg, which was weaker than healthy individuals but better than RA with high disease activity, showing a similar trend in ROM, which may be related to less pain. Our study revealed that handgrip strength and ROM were significantly greater in the YJJG than CG at 12 weeks ($p < 0.05$), indicating that Yijinjing exercise could effectively improve hand muscle strength and ameliorate hand flexibility. This finding was consistent with Mark A Williams[48], but due to the use of different grip devices, we did not measure the pinch grip force, which was one of the limitations of our study. The lack of a healthy ROM can be explained as follows. First, this study was carried out in RA patients with constant hand dysfunction. Second, even though the RA is relatively stable, still exists subclinical synovitis, referred to as synovitis under ultrasound or MRI, still exists with no signs of joint swelling. In addition, this may be related to the insufficient length of the intervention. However, there is no standard method for measuring RA joint mobility. Naoto Ienaga[49] developed a smartphone-based system to assess the ROM of the wrist joint, whose accuracy was within a clinically usable error range. The Yijinjing exercise contains multiple hand or wrist movements. As a result, Yijinjing can effectively promote muscular strength and dexterity in the hand.

Yijinjing did not increase inflammation in RA patients. As recommended by the EULAR[50], the semi-quantitative grading of musculoskeletal ultrasound is more sensitive for diagnosing subclinical synovitis in the wrist and hand[51]. This study revealed that subclinical synovitis and tenosynovitis were present in both groups at baseline. There was a slight decrease in YJJG compared with baseline, while mild aggravation in CG after 12 weeks of intervention. Although no significant difference was found between the two groups, a gradual improvement was noted in YJJG, indicating that Yijinjing does not exacerbate synovitis and is safe for treating RA. A prospective intervention study made clear that strengthening exercise is beneficial for enhancing the cross-sectional area of the rectus femoris via ultrasonography[52]. In addition, training did not increase blood flow on ultrasound Doppler induced by inflammation, indicating that it had no adverse effect on RA[53]. Therefore, it is necessary to introduce ultrasound as an evaluation to monitor the safety of exercise in RA. If the ultrasound score significantly increases, it hints at reducing intensity or stopping temporarily.

The morning stiffness duration, patient global assessment of disease activity, TJC, SJC, RF, CRP, and ESR are associated with RA disease activity. DAS28-ESR < 2.6, as a remission criterion, may be appropriate for most patients in the clinic[54]. At 12 weeks, the above outcomes of YJJG were almost improved compared with CG, indicating that Yijinjing could further reduce the activity of stable RA, gradually run up to remission, and did not aggravate joint inflammation. The effect of aerobic exercise on the prevention and treatment of RA dysfunction and disease activity has been gradually recognized. A study affirmed that aerobic and resistance exercise improved physical fitness in terms of aerobic capacity, endurance, and strength in older adults with RA[55]. Tai Chi is safe for RA patients, but more evidence is needed to improve physical function and pain with active RA[56]. Future researchers could attach importance to exercise in ameliorating function with moderate/severe disease activity RA. Exercise can not only improve function but also control inflammation, and the best duration and intensity of exercise should be explored in the future.

Yijinjing is beneficial for mind-body function in RA patients. RA with dysfunction often affects quality of life, and RA with lower disease activity have lower HAQ scores and better mobility[57]. Depression and anxiety are common comorbidities of RA, with the prevalence of depression varying from 14–48%[58], and the prevalence of anxiety was 62.1%, which is even greater than depression[59]. Therefore, we should not only control the disease activity of RA but also pay attention to improving quality of life and mental health. It showed that the daily activities of RA in the YJJG were basically not difficult, and anxiety and depression scores were obviously reduced in our study. During the follow-up, most patients said that they expected to be able to exercise, but they were afraid that the strenuous exercise would aggravate joint disorders, and they were irritable or depressed in the long term, which not only affected mental health but

also further influenced body function. Yijinjing exercise made the patient sweat slightly, relaxed their mind and body, and they were willing to maintain the exercise. This study provided a rehabilitation treatment plan for RA patients with psychosomatic benefits.

This study had several limitations. First, our study focused on RA patients with a DAS28 < 3.2 and showed that Yijinjing is safe and effective in treating RA with low disease activity. Subsequent research can further expand the DAS28 to clarify its impact on RA with medium and high disease activity. In addition, some outcomes did not show significant differences, so exercise could be prolonged to 24 weeks to observe long-term efficacy. In addition, our sample size was not large enough; we included only one center participant and did not have a positive control. Further multi-center clinical studies could be conducted to add positive controls to obtain higher-level evidence.

In conclusion, Yijinjing exercise can improve hand function and enhance handgrip strength and flexibility in RA patients with low disease activity while ameliorating quality of life and alleviating anxiety and depression while safe and not aggravating joint inflammation.

Abbreviations

RA: rheumatoid arthritis; VAS: visual analogue scale; HAQ: Health Assessment Questionnaire Disability Index; DMARDs: disease-modifying anti-rheumatic drugs; EULAR: European League Against Rheumatism; SARAH: Strengthening and Stretching for Rheumatoid Arthritis of the Hand Trial; RCT: randomized controlled trial; MHQ: Michigan Hand Outcomes Questionnaire; ROM: range of motion of joints; SJC: number of swollen joints; TJC: number of painful joints; SAS: self-rating anxiety scale; SDS: self-rating depression scale; ECG: electrocardiogram; US: ultrasonography; ACR: American College of Rheumatology; CRF: case report form; DMC: Data Monitoring Committee.

Declarations

Ethics approval and consent to participate

The Ethics Committee of Guang'anmen Hospital, Chinese Academy of Traditional Chinese Medicine, approved the project (approval number: 2022-002-KY-01). Patients were informed both orally and in writing of the purpose and specifics of the study and signed an informed consent form before all patients were enrolled. The study registration number is NCT05527158. Recruitment began on February 2022 and will be completed by December 2022.

Consent for publication

All authors agree to the publication of identifiable data.

Availability of data and materials

The materials and related results from this study are presented in a paper.

Competing interest

All the authors declare that they have no conflicts of interest.

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Authors' contributions

QJ was the principal investigator. TC, XIM, and QwP completed the study and wrote the manuscript. XG and RmZ assessed the outcomes of the study. All authors have read and approved the final version of the manuscript.

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Protocol version 2021-10-07V1

References

1. Sparks JA. Rheumatoid Arthritis. Ann Intern Med. 2019;170(1):ITC1–16. 10.7326/AITC201901010.
2. Smolen JS, Aletaha D, Barton A, Burmester GR, Emery P, Firestein GS, Kavanaugh A, McInnes IB, Solomon DH, Strand V, Yamamoto K. Rheumatoid arthritis. Nat Rev Dis Primers. 2018;4:18001. 10.1038/nrdp.2018.1.
3. Horsten NC, Ursum J, Roorda LD, van Schaardenburg D, Dekker J, Hoeksma AF. Prevalence of hand symptoms, impairments and activity limitations in rheumatoid arthritis in relation to disease duration. J Rehabil Med. 2010;42:916–21.

4. Williams MA, Williamson EM, Heine PJ, Nichols V, Glover MJ, Dritsaki M, Adams J, Dosanjh S, Underwood M, Rahman A, McConkey C, Lord J, Lamb SE. Strengthening And stretching for Rheumatoid Arthritis of the Hand (SARAH). A randomised controlled trial and economic evaluation. Health Technol Assess. 2015;19(19):1–222. 10.3310/hta19190.
5. Bergstra SA, Murgia A, Te Velde AF, Caljouw SR. A systematic review into the effectiveness of hand exercise therapy in the treatment of rheumatoid arthritis. Clin Rheumatol. 2014;33:1539–48.
6. Rodríguez-Sánchez-Laulhé P, Luque-Romero LG, Blanquero J, Suero-Pineda A, Biscarri-Carbonero Á, Barrero-García FJ, Heredia-Rizo AM. A mobile app using therapeutic exercise and education for self-management in patients with hand rheumatoid arthritis: a randomized controlled trial protocol. Trials. 2020;21(1):777. 10.1186/s13063-020-04713-4.
7. Filairea E, Toumib H. Reactive oxygen species and exercise on bone metabolism: friend or enemy? Joint Bone Spine. 2012;79:341–6.
8. Aletaha D, Neogi T, SilmanAJ et al. Arthritis Rheum 2010 Rheumatoid arthritis classification criteria: an American College of Rheumatology/European League Against Rheumatism collabora-tive initiative 2010; 62 (9): 2569–81.
9. Peter WF, Swart NM, Meerhoff GA, Vliet Vlieland TPM. Clinical Practice Guideline for Physical Therapist Management of People With Rheumatoid Arthritis. Phys Ther. 2021;101(8):pzab127. 10.1093/ptj/pzab127.
10. England BR, Smith BJ, Baker NA, et al. 2022 American College of Rheumatology Guideline for Exercise, Rehabilitation, Diet, and Additional Integrative Interventions for Rheumatoid Arthritis. Arthritis Rheumatol. 2023;75(8):1299–311.
11. Hu H, Xu A, Gao C, et al. The effect of physical exercise on rheumatoid arthritis: An overview of systematic reviews and meta-analysis. J Adv Nurs. 2021;77(2):506–22. 10.1111/jan.14574. Epub 2020 Nov 11.
12. Sobue Y, Kojima T, Ito H, Nishida K, Matsushita I, et al. Does exercise therapy improve patient-reported outcomes in rheumatoid arthritis? A systematic review and meta-analysis for the update of the 2020 JCR guidelines for the management of rheumatoid arthritis. Mod Rheumatol. 2022;32(1):96–104. 10.1080/14397595.2021.1886653.
13. Lamb SE, Williamson EM, Heine PJ, et al. Exercises to improve function of the rheumatoid hand (SARAH): a randomised controlled trial. Lancet. 2015;385(9966):421–9. 10.1016/S0140-6736(14)60998-3. Epub 2014 Oct 9.
14. Kjeken I. A tailored hand exercise program improves function of the rheumatoid hand. J Physiother. 2015;61(2):96. 10.1016/j.jphys.2015.02.007. Epub 2015 Mar 20.
15. Williams MA, Williamson EM, Heine PJ, et al. Strengthening And stretching for Rheumatoid Arthritis of the Hand (SARAH). A randomised controlled trial and economic evaluation. Health Technol Assess. 2015;19(19):1–222. 10.3310/hta19190.
16. Nichols VP, Williamson E, Toye F, Lamb SE. A longitudinal, qualitative study exploring sustained adherence to a hand exercise programme for rheumatoid arthritis evaluated in the SARAH trial. Disabil Rehabil. 2017;39(18):1856–63.
17. Williamson E, McConkey C, Heine P, et al. Hand exercises for patients with rheumatoid arthritis: an extended follow-up of the SARAH randomised controlled trial. BMJ Open. 2017;7(4):e013121. 10.1136/bmjopen-2016-013121.
18. Williams MA, Srikesavan C, Heine PJ et al. Exercise for rheumatoid arthritis of the hand. Cochrane Database Syst Rev. 2018;7(7).
19. Zhang S, Guo G, Li X, Yao F, Wu Z, Zhu Q, Fang M. The Effectiveness of Traditional Chinese Yijinjing Qigong Exercise for the Patients With Knee Osteoarthritis on the Pain, Dysfunction, and Mood Disorder: A Pilot Randomized Controlled Trial. Front Med (Lausanne). 2022;8:792436. 10.3389/fmed.2021.792436.
20. Chen Y, Ma Y, Zhang Z, Zhang Y, Jia J. The efficacy and safety of Yijinjing exercise in the adjuvant treatment of ankylosing spondylitis: A protocol of randomized controlled trial. Med (Baltim). 2021;100(38):e27109.
21. Cheng Z, Chen Z, Xie F, Guan C, Gu Y, Wang R, You Y, Yao F. Efficacy of Yijinjing combined with Tuina for patients with non-specific chronic neck pain: study protocol for a randomized controlled trial. Trials. 2021;22(1):586. 10.1186/s13063-021-05557-2.
22. Xue X, Jin XM, Luo KL, Liu XH, Zhang L, Hu J. Effectiveness of Yijinjing on cognitive functions in post-stroke patients with mild cognitive impairment: study protocol for a randomized controlled trial. Trials. 2021;22(1):265. 10.1186/s13063-021-05220-w.
23. Gao H, Luo C, Tu SJ, Lu RP, Jiang LN, Qiao HJ, Lin Q, Li NN, Chen JH. The Effect of Yijinjing on the Cognitive Function of Patients With Chronic Schizophrenia. Front Psychiatry. 2021;12:739364. 10.3389/fpsyt.2021.739364.
24. Liu Fang. Study on the improvement of the function of affected limbs in patients with rheumatoid arthritis by fitness qigong-Yi Jin Jing[D]. Beijing Sports University; 2013.
25. Shauver MJ, Chung KC. The minimal clinically important difference of the Michigan hand outcomes questionnaire. J Hand Surg Am. 2009;34:509–14.
26. Jayaram M, Wang C, Wang L, Chung KC. Validating the Michigan Hand Outcomes Questionnaire in patients with rheumatoid arthritis using Rasch analysis. PLoS ONE. 2021;16(7):e0254984. 10.1371/journal.pone.0254984.
27. Chung KC, Pillsbury MS, Walters MR, Hayward RA. Reliability and validity testing of the Michigan Hand Outcomes Questionnaire. J Hand Surg. 1998;23A(4):575–87.
28. Hogrel JY. Grip strength measured by high precision dynamometry in healthy subjects from 5 to 80 years. BMC Musculoskelet Disord. 2015;16:139.
29. Shiratori AP, Iop Rda R, Borges Júnior NG, Domenech SC, Gevaerd Mda S. Evaluation protocols of hand grip strength in individuals with rheumatoid arthritis: a systematic review. Rev Bras Reumatol. 2014 Mar-Apr;54(2):140-7. English, Portuguese.
30. Rodríguez-Sánchez-Laulhé P, Luque-Romero LG, Blanquero J, Suero-Pineda A, Biscarri-Carbonero Á, Barrero-García FJ, Heredia-Rizo AM. A mobile app using therapeutic exercise and education for self-management in patients with hand rheumatoid arthritis: a randomized controlled trial protocol. Trials. 2020;21(1):777. 10.1186/s13063-020-04713-4.

31. Zhang L, Cao H, Zhang Q, Fu T, Yin R, Xia Y, Li L, Gu Z. Motion analysis of the wrist joints in Chinese rheumatoid arthritis patients: a cross-sectional study. BMC Musculoskelet Disord. 2018;19(1):270. 10.1186/s12891-018-2146-z.
32. Massy-Westropp N, Ahern M, Krishnan J. A visual analogue scale for assessment of the impact of rheumatoid arthritis in the hand: validity and repeatability. J Hand Ther. 2005 Jan-Mar;18(1):30–3. 10.1197/j.jht.2004.10.003.
33. Tuominen R, Möttönen T, Suominen C, et al. Relative importance of the functional abilities comprising Health Assessment Questionnaire Disability Index among rheumatoid arthritis patients. Rheumatol Int. 2010;30:1477–82.
34. Carter JD, Lodhi AB, Nagda SR, Ricca L, Ward C, Traina E, Thompson ZJ, Huang Y, Valeriano J, Vasey FB. Determining rheumatologists' accuracy at assessing functional disability in rheumatoid arthritis patients using the Health Assessment Questionnaire-Disability Index. J Rheumatol. 2007;34(5):958–63. Epub 2007 Apr 1.
35. Geng Y, Gao T, Zhang X, Wang Y, Zhang Z. The association between disease duration and mood disorders in rheumatoid arthritis patients. Clin Rheumatol. 2022;41(3):661–8. 10.1007/s10067-021-05967-2. Epub 2021 Oct 24.
36. Terslev L, Naredo E, Aegerter P, et al. Scoring ultrasound synovitis in rheumatoid arthritis: a EULAR-OMERACT ultrasound task force-Part 2: reliability and application to multiple joints of a standardised consensus-based scoring system. RMD Open. 2017;3:e000427.
37. Kroon FPB, Boersma A, Boonen A, et al. Performance of the Michigan Hand Outcomes Questionnaire in hand osteoarthritis. Osteoarthritis Cartilage. 2018;26(12):1627–35.
38. Durmus D, Uzuner B, Durmaz Y, et al. Michigan Hand Outcomes Questionnaire in rheumatoid arthritis patients: relationship with disease activity, quality of life, and handgrip strength. J Back Musculoskelet Rehabil. 2013;26(4):467–73.
39. Williams MA, Williamson EM, Heine PJ, et al. Strengthening And stretching for Rheumatoid Arthritis of the Hand (SARAH). A randomised controlled trial and economic evaluation. Health Technol Assess. 2015;19(19):1–222.
40. Higgins SC, Adams J, Hughes R. Measuring hand grip strength in rheumatoid arthritis. Rheumatol Int. 2018;38:707–14.
41. Özeri Z, Çakýt BD, Taþkýn S et al. The relationships among functional impairment, disability and articular damage in rheumatoid hand. J Phys Med Rehabil Sci 2:200853–58.
42. Yayama T, Kobayashi S, Kokubo Y, et al. Motion analysis of the wrist joints in patients with rheumatoid arthritis. Mod Rheumatol. 2007;17(4):322–6.
43. Palamar D, Er G, Terlemez R, et al. Disease activity, handgrip strengths, and hand dexterity in patients with rheumatoid arthritis. Clin Rheumatol. 2017;36(10):2201–8.
44. Navarro-Compán V, Landewé R, Provan SA, et al. Relationship between types of radiographic damage and disability in patients with rheumatoid arthritis in the EURIDISS cohort: a longitudinal study. Rheumatology. 2015;54(1):83–90.
45. Fan S, Cepek J, Symonette C, et al. Variation of Grip Strength and Wrist Range of Motion with Forearm Rotation in Healthy Young Volunteers Aged 23 to 30. J Hand Microsurg. 2019;11(2):88–93.
46. Žura N, Vukorepa M, Jurak I, et al. Decrease in handgrip strength in rheumatoid arthritis (RA): is there a sex-related difference? Rheumatol Int. 2021;41:1795–802.
47. Zhang L, Cao H, Zhang Q, et al. Motion analysis of the wrist joints in Chinese rheumatoid arthritis patients: a cross-sectional study. BMC Musculoskelet Disord. 2018;19(1):270.
48. Williams MA, Williamson EM, Heine PJ, et al. Strengthening And stretching for Rheumatoid Arthritis of the Hand (SARAH). A randomised controlled trial and economic evaluation. Health Technol Assess. 2015;19(19):1–222.
49. Ienaga N, Fujita K, Koyama T, et al. Development and User Evaluation of a Smartphone-Based System to Assess Range of Motion of Wrist Joint. J Hand Surg Glob Online. 2020;2(6):339–42.
50. Colebatch AN, Edwards CJ, Østergaard M, et al. EULAR recommendations for the use of imaging of the joints in the clinical management of rheumatoid arthritis. Ann Rheum Dis. 2013;72:804–14.
51. Huang Y, Liu KJ, Chen GW, et al. Diagnostic value of semi-quantitative grading of musculoskeletal ultrasound in wrist and hand lesions of subclinical synovitis in rheumatoid arthritis. Am J Nucl Med Mol Imaging. 2022;12(1):25–32.
52. Sul B, Lee KB, Joo YB, et al. Twelve Weeks of Strengthening Exercise for Patients with Rheumatoid Arthritis: A Prospective Intervention Study. J Clin Med. 2020;9(9):2792.
53. Ellegaard K, Torp-Pedersen S, Lund H, et al. The effect of isometric exercise of the hand on the synovial blood flow in patients with rheumatoid arthritis measured by color Doppler ultrasound. Rheumatol Int. 2013;33:65–70.
54. Ramírez J, Inciarte-Mundo J, Cuervo A, et al. Comparable long-term outcomes between DAS28-ESR remission criteria and ACR/EULAR definitions in patients with established rheumatoid arthritis. Clin Rheumatol. 2021;40:2665–72.
55. Lange E, Kucharski D, Svedlund S, Svensson K, Bertholds G, Gjertsson I, Mannerkorpi K. Effects of Aerobic and Resistance Exercise in Older Adults With Rheumatoid Arthritis: A Randomized Controlled Trial. Arthritis Care Res. 2019;71:61–70.
56. Wu H, Wang Q, Wen G, Wu J, Wang Y. The effects of Tai Chi on physical function and safety in patients with rheumatoid arthritis: A systematic review and meta-analysis. Front Physiol. 2023;14:1079841.
57. Rosa-Gonçalves D, Bernardes M, Costa L. Quality of life and functional capacity in patients with rheumatoid arthritis - Cross-sectional study. Reumatol Clin (Engl Ed). 2018 Nov-Dec;14(6):360–6.
58. Faith Matcham L, Rayner, December, Sophia Steer. The prevalence of depression in rheumatoid arthritis: a systematic review and meta-analysis, Rheumatology, 52, Issue 12, 2013, Pages 2136–48.

59. Hill J, Harrison J, Christian D, et al. The prevalence of comorbidity in rheumatoid arthritis: a systematic review and meta-analysis. Br J Community Nurs. 2022;27(5):232–41.

Figures

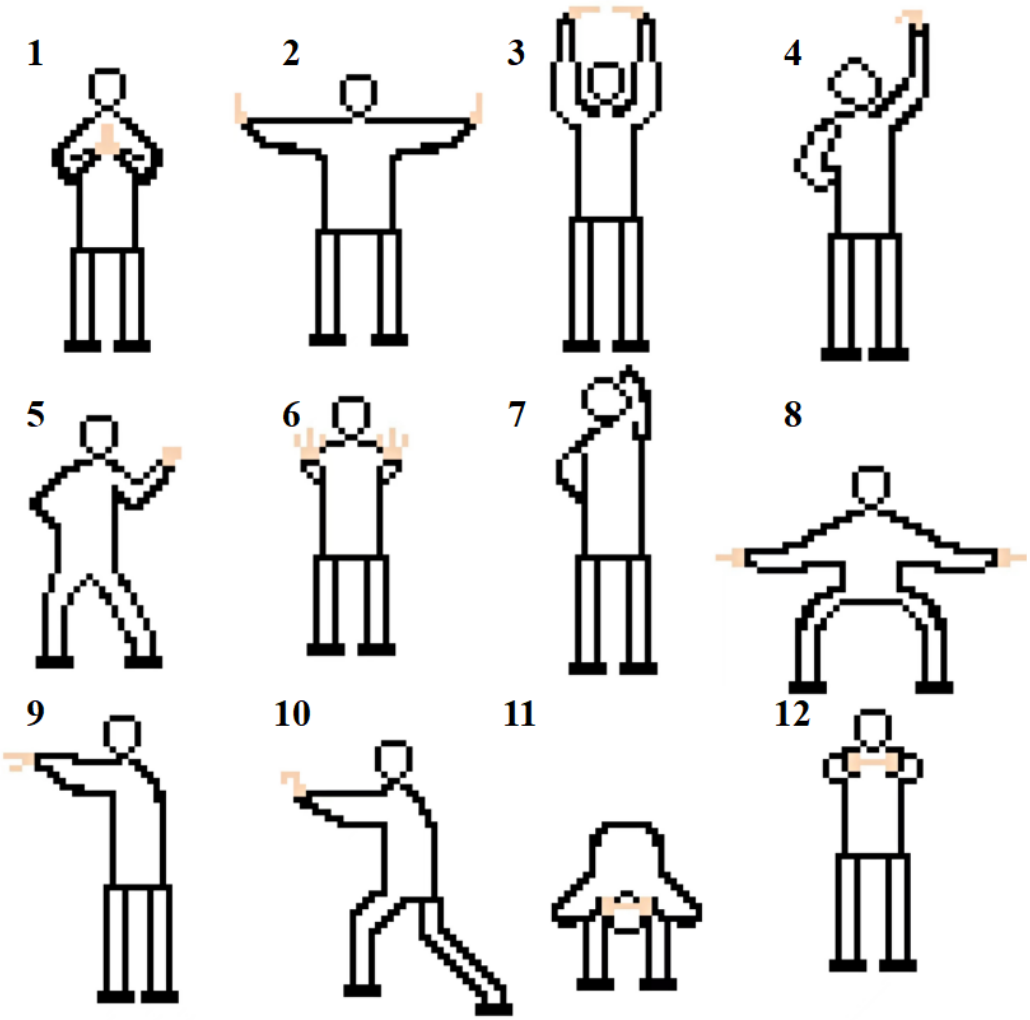

Figure 1

Twelve postures of Yijinjing exercise.

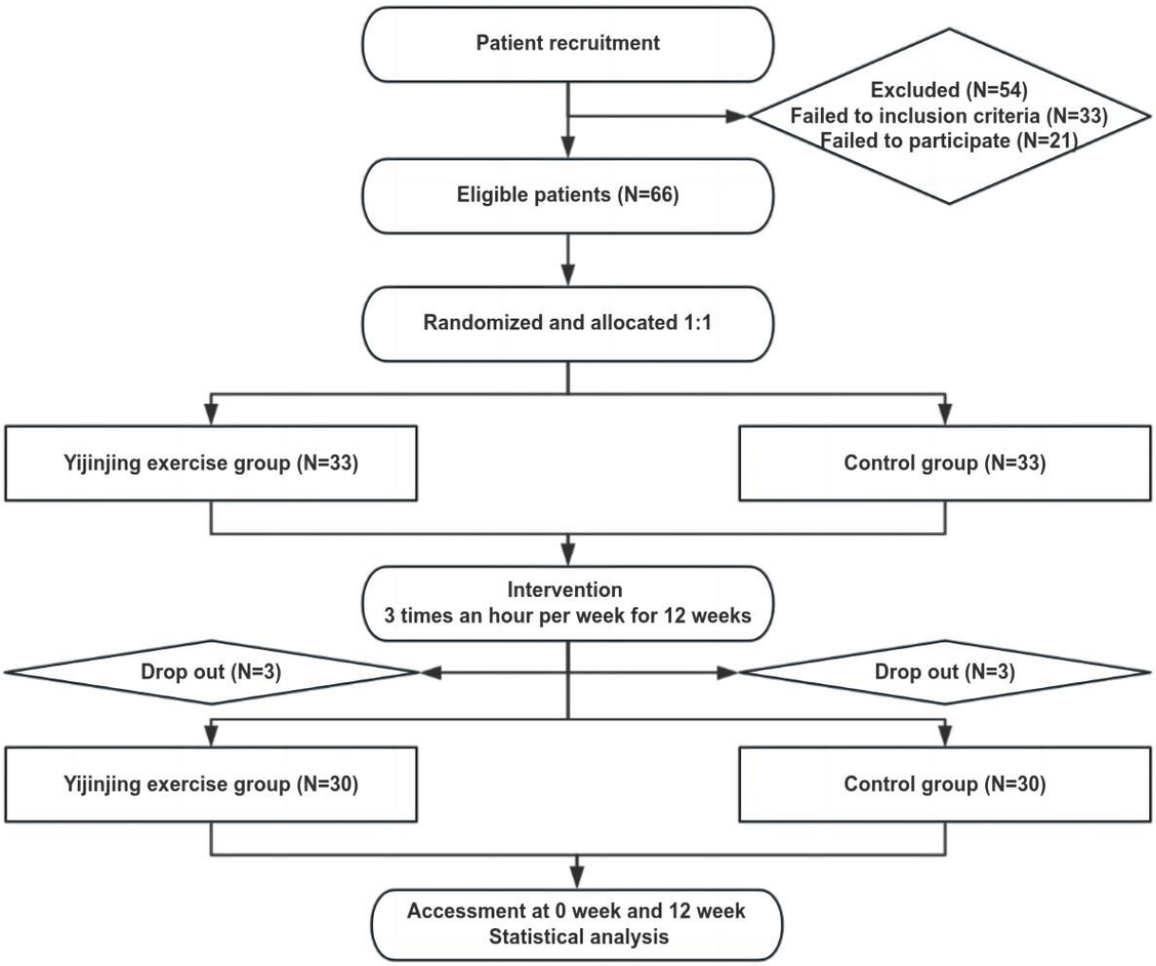

Figure 2

Participant flow diagram.