Original Paper

Home-Based, Digitally Assisted Dyadic Tai Chi Intervention for Patients With Chronic Heart Failure and Their Caregivers: Development of an Intervention and Pilot Randomized Controlled Trial

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Abstract

Background: Chronic heart failure (CHF) imposes a dual and dynamically interrelated burden on patients and family caregivers, whose health and illness management behaviors are interdependent. Exercise interventions that actively engage the patient-caregiver dyad as the unit of rehabilitation in the home setting remain underdeveloped.

Objective: This study aimed to develop a home-based, digitally assisted, dyadic tai chi (HDTC) intervention and evaluate its feasibility, acceptability, safety, and preliminary effects among dyads of patients with CHF and their caregivers.

Methods: This sequential, multiphase study comprised intervention development followed by a single-center, assessor-blinded, parallel-group pilot randomized controlled trial. Phase 1 integrated literature review, theoretical frameworks, and stakeholder focus group interviews to develop and refine the HDTC intervention. In phase 2, eligible adults with CHF (aged 18-75 years; New York Heart Association class I-III) and their primary caregivers were recruited from a tertiary medical center in Qingdao, China, from October 14 to November 12, 2024, and followed for 12 weeks. Forty dyads were allocated 1:1 to the 12-week HDTC intervention plus usual care or usual care alone (n=20 per group). Outcome assessors and the data analyst were blinded to group allocation. Feasibility, acceptability, and safety were the primary focus of the pilot trial. Patient, caregiver, and dyadic health outcomes were preliminarily explored at baseline and 4 and 12 weeks. All 40 randomized dyads were included in the intention-to-treat analyses.

Results: The HDTC intervention comprised an online educational seminar, nurse-led dyadic coaching, preliminary face-to-face tai chi training, and supervised HDTC practice. The recruitment rate was 83.3% (40/48), mean session attendance was 73.7% (SD 8.6%), and 70% (14/20) of participants achieved high adherence rate (≥75% attendance). All intervention dyads rated the intervention as acceptable. No intervention-related adverse events were identified. Exploratory generalized estimating equation analyses suggested greater improvements from baseline to 12 weeks in the intervention group than in the control group in functional capacity (β=38.858; *P*=.001), together with greater reductions in Minnesota Living With Heart Failure Questionnaire scores (β=−1.850; *P*=.002), sedentary time (β=−1.025; *P*=.01), and fear of activity (β=−6.550; *P*=.01). Caregiver burden also decreased (β=−4.350; *P*<.001), while mutuality improved more for both patients (β=10.508; *P*<.001) and caregivers (β=6.450; *P*<.001).

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Conclusions: The HDTC intervention was feasible and acceptable, with preliminary improvements across patient, caregiver, and dyadic outcomes. By integrating shared patient-caregiver participation with digitally supported home-based tai chi, the HDTC intervention extends patient-centered rehabilitation toward a dyad-oriented model. If confirmed in a fully powered trial, this approach may offer a practical strategy for expanding home-based cardiac rehabilitation.

Trial Registration: ClinicalTrials.gov NCT06876441; https://clinicaltrials.gov/study/NCT06876441

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KEYWORDS

heart failure; caregivers; home-based rehabilitation; tai chi; dyadic intervention

Introduction

Heart failure (HF) remains a prevalent and burdensome chronic condition worldwide [1,2]. Patients with HF commonly exhibit high levels of sedentary behavior, which are associated with increased risks of hospitalization and mortality [3]. Although exercise-based cardiac rehabilitation is recommended to improve functional outcomes and prognosis [4], participation in center-based programs remains low because of travel, scheduling, and service capacity barriers [5]. Digitally supported home-based exercise rehabilitation offers a potential alternative, although evidence regarding its safety, feasibility, and effects in HF remains limited [6].

Within the home setting, exercise is embedded in the family context, with caregivers often providing encouragement, safety monitoring, scheduling support, and reinforcement of continued participation [7]. Meanwhile, caregivers experience substantial caregiving burden that can adversely affect their own physical and psychological health [8,9], which may in turn influence patient outcomes [10]. This reciprocal influence supports conceptualizing the patient-caregiver dyad, rather than the patient alone, as a target of intervention [11,12]. However, dyadic intervention research in HF remains limited [13], and existing interventions have focused primarily on self-care and psychosocial support, with relatively little attention to structured exercise jointly undertaken by patients and caregivers [14,15].

Dyadic exercise extends conventional patient-centered rehabilitation by engaging both members of the dyad in a shared health behavior [16]. Consistent with the theory of dyadic illness management, which emphasizes reciprocal influences within the dyad [17], this approach moves beyond targeting patient behavior alone. It also differs from caregiver-supported self-care, in which caregivers primarily facilitate patient disease management; shared exercise actively involves both members and may benefit both while strengthening mutual support and dyadic relationship quality [11].

Tai chi, a moderate-intensity aerobic exercise, is recommended as an adjunctive therapy in international HF management guidelines [18,19]. Prior studies suggest that it may enhance exercise capacity, psychological well-being, and quality of life (QoL) in patients with chronic HF (CHF) [20,21], but practical barriers, including travel demands, time constraints, self-discipline challenges, and limited access to qualified masters, hinder patients' access to center-based practice [22], underscoring the need for home-based, digitally assisted tai chi. Previous evidence has revealed that digitally assisted tai chi, in which all components are delivered through an online platform without face-to-face instruction, is feasible and effective among other frail populations [23]. To date, however, the integration of tai chi into dyadic management models remains largely unexplored.

To address these gaps, this study aimed to systematically develop a home-based, digitally assisted, dyadic tai chi (HDTC) intervention for patients with CHF and their family caregivers. Then, a pilot randomized controlled trial (RCT) was conducted to evaluate its feasibility, acceptability, and safety and explore preliminary effects on patient, caregiver, and dyadic outcomes.

Methods

Study Design and Setting

This sequential multimethod study guided by the Medical Research Council framework comprised 2 stepwise phases [24]. Phase 1 developed the HDTC intervention for dyads through (1) iterative evidence synthesis (literature review, systematic review of digitally assisted interventions, and scoping review of caregiver roles), (2) application of theoretical frameworks to inform a stage transition model for sustained dyadic exercise, and (3) focus group interviews with key stakeholders (physicians, nurses, patients with CHF, caregivers, and tai chi master) to refine the digital implementation of the intervention. Phase 2 was a prospective, 2-arm pilot RCT conducted at a tertiary medical center in Qingdao, China, evaluating the feasibility, acceptability, and preliminary effects of the HDTC intervention. This pilot RCT was reported in accordance with the CONSORT (Consolidated Standards of Reporting Trials) 2010 extension for randomized pilot and feasibility trials [25] (Multimedia Appendix 1).

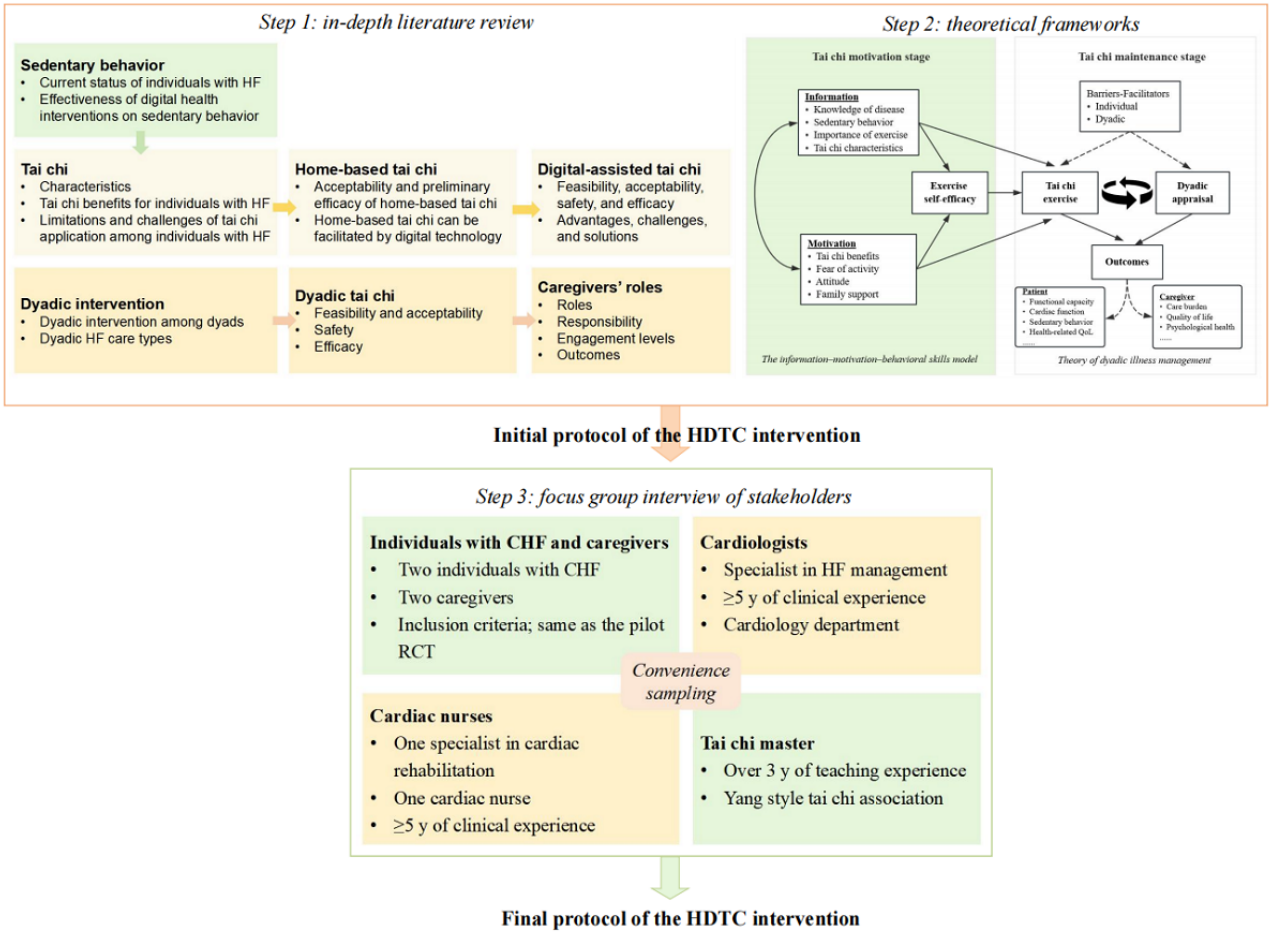
Phase 1: Development of the HDTC Intervention

The intervention was developed through 3 sequential steps. First, an iterative evidence synthesis via literature review identified key components informing the HDTC intervention protocol: sedentary behavior, digital health interventions, home-based tai chi, dyadic tai chi, and caregiver roles. Second, 2 theoretical frameworks guided the transition from sedentary behavior to sustained tai chi exercise: the information-motivation–behavioral skills model and theory of dyadic illness management. The information-motivation–behavioral skills model was used primarily to structure the initial transition from sedentary behavior to exercise participation (*tai chi motivation stage*) [26,27]. The educational seminar addressed exercise-related

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information, the dyadic coaching session explored motivation and shared goals, and introductory tai chi training was used to develop the behavioral skills required for safe home practice. The theory of dyadic illness management informed the subsequent maintenance phase (*tai chi maintenance stage*) [17]. In this phase, patients and caregivers were encouraged to view exercise as a shared rehabilitation task, coordinate participation and support, monitor progress, and address exercise-related challenges collaboratively. Digital communication, shared reminders, and professional feedback were incorporated to support continued dyadic engagement. Third, focus group interviews were conducted with key stakeholders, comprising 2 dyads (2 patients and their respective caregivers), 2 cardiologists and 2 nurses with more than 5 years of experience in HF management, and 1 tai chi master with 11 years of teaching experience from the Yang Style Tai Chi Association. The interview guide was designed based on the nonadoption, abandonment, scale-up, spread, and sustainability framework (Multimedia Appendix 2) to enhance the practicality and adaptability of the digital intervention [28]. The intervention was subsequently refined based on stakeholder feedback. The flow diagram of the intervention development is shown in Figure 1.

Figure 1. The home-based, digital-assisted, dyadic tai chi (HDTC) was systematically developed through 3 steps: literature review, theory-guided intervention design, and stakeholder consultation. CHF: chronic heart failure; HF: heart failure; RCT: randomized controlled trial.



Phase 2: Pilot-Testing of the HDTC Intervention

Participants and Sample Size

A convenience sample of 40 dyads of patients with CHF and their caregivers was recruited from the Affiliated Hospital of Qingdao University. The inclusion criteria for patients with CHF were (1) age of 18 to 75 years with a diagnosis of CHF [29]; (2) New York Heart Association class I, II, or III and 6-minute walk test distance of more than 150 m [29]; (3) ability to perform the prescribed tai chi movements without physical assistance, as assessed during pre-enrollment screening; (4) smartphone ownership; and (5) voluntary participation and informed consent. Exclusion criteria were as follows: planned surgery within 6 months; severe comorbidities such as cancer, liver or kidney failure, and diagnosed psychiatric disorders; planned relocation to care facilities; regular exercise in the prior 3 months; or concurrent trial participation. Caregiver inclusion criteria were age of 18 years or older, being primary caregivers for patients with CHF [30], ability to practice tai chi without help, and voluntary participation and informed consent.

On the basis of pilot trial recommendations, at least 15 participants per group were required to detect a medium effect size assuming a 90% power with a 2-sided 5% significance level [31]. Accounting for 20% attrition, 18 dyads per group were targeted.

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Recruitment of Dyads of Patients With CHF and Their Caregivers

Potential patients with CHF were recruited through electronic advertisements with QR codes displayed in the HF clinic and cardiology department and via electronic questionnaires disseminated to 30 WeChat groups of discharged patients. After initial prescreening, eligible patients underwent a comprehensive assessment followed by screening of their caregivers. Informed consent was obtained from all dyads prior to enrollment.

Randomization, Allocation Concealment, and Blinding

Randomization was performed by an independent individual using the Sealed Envelope online tool [32]. Allocation used a 1:1 ratio with stratification by New York Heart Association class (I, II, and III) and block sizes of 4 and 6. Allocation concealment was ensured through sequentially numbered, opaque, sealed envelopes opened only after baseline assessments. Owing to the nature of the behavioral intervention, blinding of intervention providers and participants was not feasible [33]; only outcome assessors and the data analyst were blinded to group allocation.

Interventions

HDTC Intervention

Dyads in the intervention group participated in the HDTC intervention plus usual care. The intervention was delivered over 12 weeks, consistent with the duration commonly used in previous tai chi studies among patients with CHF [16]. The contents of the intervention are detailed in the Results section.

Control Group

Dyads in the control group received usual care, including online comprehensive education and nurse-led telephone consultations. Consultations addressed symptom management, medication adherence, dietary and exercise suggestions, psychosocial support, and regular follow-ups. Caregivers served as both partners and facilitators, assisting patients with CHF in implementing these recommendations.

Intervention Fidelity

The Behavior Change Consortium framework was adopted to guide fidelity assurance [34]. First, the initial HDTC protocol was developed through a rigorous 3-stage process to ensure design integrity. Second, a tai chi master received standardized training from a cardiac rehabilitation nurse on intervention delivery, safety protocols, and participant characteristics, with ongoing researcher supervision throughout all sessions to maintain protocol adherence. Third, all tai chi sessions were delivered by a single master from the Qingdao Yang Style Tai Chi Association with 11 years of teaching experience. The master was scheduled to deliver all sessions throughout the 12-week intervention to ensure consistency in intervention delivery. If the master was unavailable, the affected session was rescheduled to maintain continuity of the intervention. Upon completion of the tai chi form learning, the master assessed participants' skill mastery. Additionally, all online classes were recorded, with an independent expert conducting a random audit of 20% of recorded classes to evaluate intervention fidelity.

Outcomes

Assessments were conducted at baseline (T0) and 4 weeks (T1), and 12 weeks (T2) of the intervention to evaluate the feasibility, acceptability, and preliminary effects of the HDTC intervention.

Feasibility

Feasibility was assessed through the recruitment period, recruitment rate, attendance rate, adherence rate, and attrition rate. Adherence was calculated as the proportion of completed tai chi classes to total prescribed classes, with high adherence defined as attendance to at least 75% of classes, consistent with previous studies [35].

Acceptability

Acceptability was assessed after the intervention using separate patient and caregiver questionnaires based on the theoretical framework of acceptability, covering affective attitude, burden, ethicality, perceived effectiveness, intervention coherence, self-efficacy, opportunity costs, and overall acceptability [36]. Each domain was rated using domain-specific ordered response options. Responses were dichotomized as favorable or unfavorable according to the positive response categories for each domain; for overall acceptability, "acceptable" and "completely acceptable" were classified as favorable. The intervention was considered acceptable if 80% or more of the participants provided a favorable overall rating [37].

Adverse Events

Consistent with the CONSORT Harms statement [38], adverse events were defined as any possible adverse consequences attributable to the intervention. Potential adverse events, including dyspnea, palpitations, chest pain, arrhythmia, myocardial infarction, falls, and other unexpected symptoms, were recorded by a nurse and subsequently assessed by a physician to determine their relationship to the intervention.

Preliminary Effects

Outcomes of Patients With CHF

The functional capacity of patients with CHF was assessed using the 6-minute walk test through the Walker Doctor Intelligent 6-Minute Walk Test Monitoring and Analysis System [39,40]. Sedentary behavior and fear of activity were evaluated using the International Physical Activity Questionnaire–Short Form [41] and Fear of Activity in Patients With Chronic Heart Failure [42], respectively. Confidence in exercising was assessed using the Self-Efficacy for Exercise Scale [43]. The Minnesota Living With Heart Failure Questionnaire was used to measure patients' health-related QoL [44].

Outcomes of Caregivers

The Chinese version of the Zarit Caregiver Burden Interview was used to measure caregivers' perceived caring burden [45], and their QoL was assessed using the Chinese Family Caregiver Quality of Life Scale [46].

Outcomes of Dyads

Mutuality, the relationship between patients with CHF and their caregivers, was measured using the Chinese Mutuality Scale [47], with higher scores denoting better mutuality.

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Data Analysis

Statistical analyses were performed using SPSS Statistics (version 26; IBM Corp). Descriptive statistics summarized participant characteristics and assessed feasibility and acceptability outcomes. Normality was evaluated using the Shapiro-Wilk test. Preliminary effects were examined using 2-tailed paired *t* tests or Wilcoxon signed-rank tests for within-group comparisons and independent *t* tests or Mann-Whitney *U* tests for between-group comparisons. Generalized estimating equation models with an independence working correlation structure and robust SEs were used to assess between-group differences across multiple time points. Missing data were assessed using the Little missing completely at random (MCAR) test to evaluate the missingness pattern. All analyses followed the intention-to-treat principle. Effect sizes were calculated using the Cohen *d* (small effect size: $d \leq 0.2$; medium effect size: $d \leq 0.5$; large effect size: $d \geq 0.8$) [48].

Ethical Considerations

This study was approved by the ethics committees of Hong Kong Polytechnic University (HSEARS20240904005) and the Affiliated Hospital of Qingdao University (QYFYWZLL29400). Written informed consent was obtained from all participating patients and caregivers before enrollment. To protect participants' privacy and confidentiality, study data were deidentified and stored securely, with access restricted to authorized research personnel. Participants received no financial compensation for taking part in the study. No identifiable images of participants are included in the manuscript or supplementary materials.

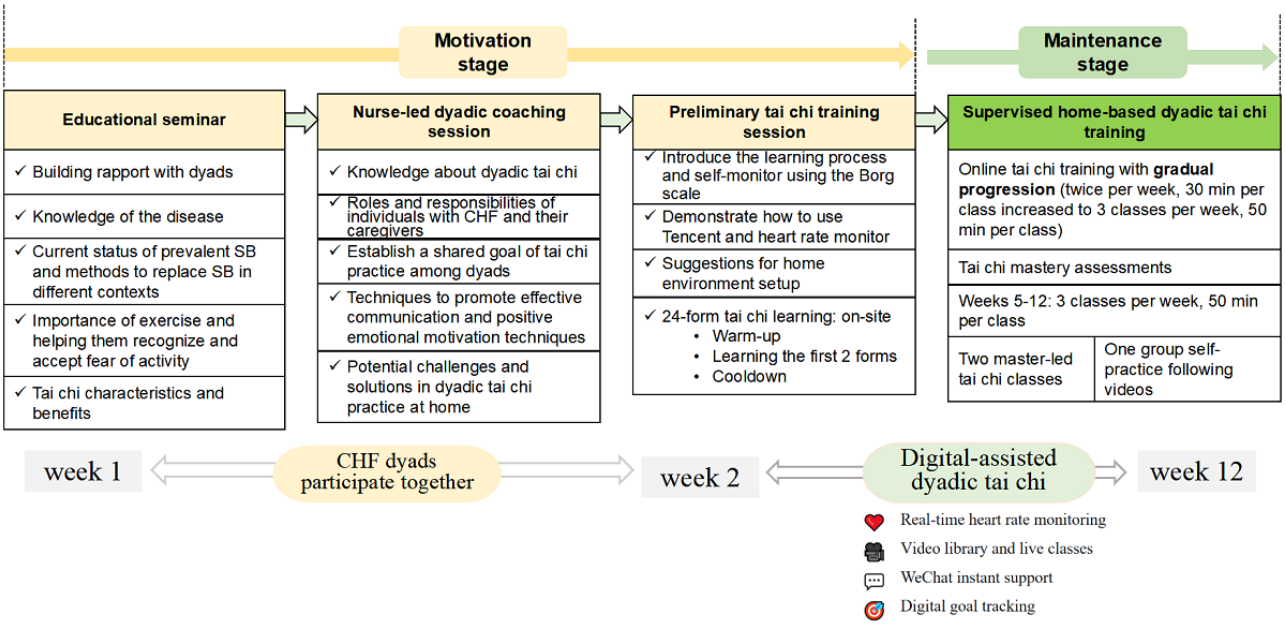
Results

HDTC Intervention Protocol

Intervention Components and Delivery

The HDTC intervention was informed by multiple sources: a systematic review on digital health interventions for sedentary behavior [49], a scoping review of caregiver roles and engagement levels [50], and focus group interviews with stakeholders (Multimedia Appendix 3). The final intervention comprised 4 components delivered in a structured sequence: an online educational seminar and a nurse-led online dyadic coaching session in week 1, an introductory face-to-face training session of 24-form Yang-style tai chi in week 2, and nurse-supervised HDTC classes (Figure 2). The tai chi sessions were delivered by a master from the Qingdao Yang Style Tai Chi Association with 11 years of teaching experience. During weeks 2 to 4, dyads attended live online tai chi classes, with the frequency and duration progressively increasing from two 30-minute sessions to three 50-minute sessions per week. During weeks 5 to 12, dyads participated in 2 master-led online sessions and 1 video-guided group practice session each week, with each session lasting 50 minutes. During supervised online sessions, a cardiac nurse monitored participants' exercise-related symptoms and heart rate and provided safety guidance as needed.

Figure 2. Protocol for the home-based, digital-assisted, dyadic tai chi intervention. The intervention comprised 4 components delivered across 2 stages: the motivation stage and the maintenance stage. Digital support included real-time heart rate monitoring, instructional videos, live online classes, WeChat-based support, and goal tracking. CHF: chronic heart failure; SB: sedentary behavior.



Digitally Assisted Features

The HDTC intervention was supported by a multifunctional digital infrastructure. Synchronous live video sessions and an on-demand video library delivered structured, progressive tai chi instruction. Real-time heart rate monitoring enhanced safety by enabling continuous oversight of patients during home-based practice. Asynchronous communication via WeChat offered ongoing access to nursing support and peer interaction, thereby reinforcing adherence. Meanwhile, digital goal-tracking features, such as shared progress updates and reminders in the online community via WeChat group, fostered shared accountability

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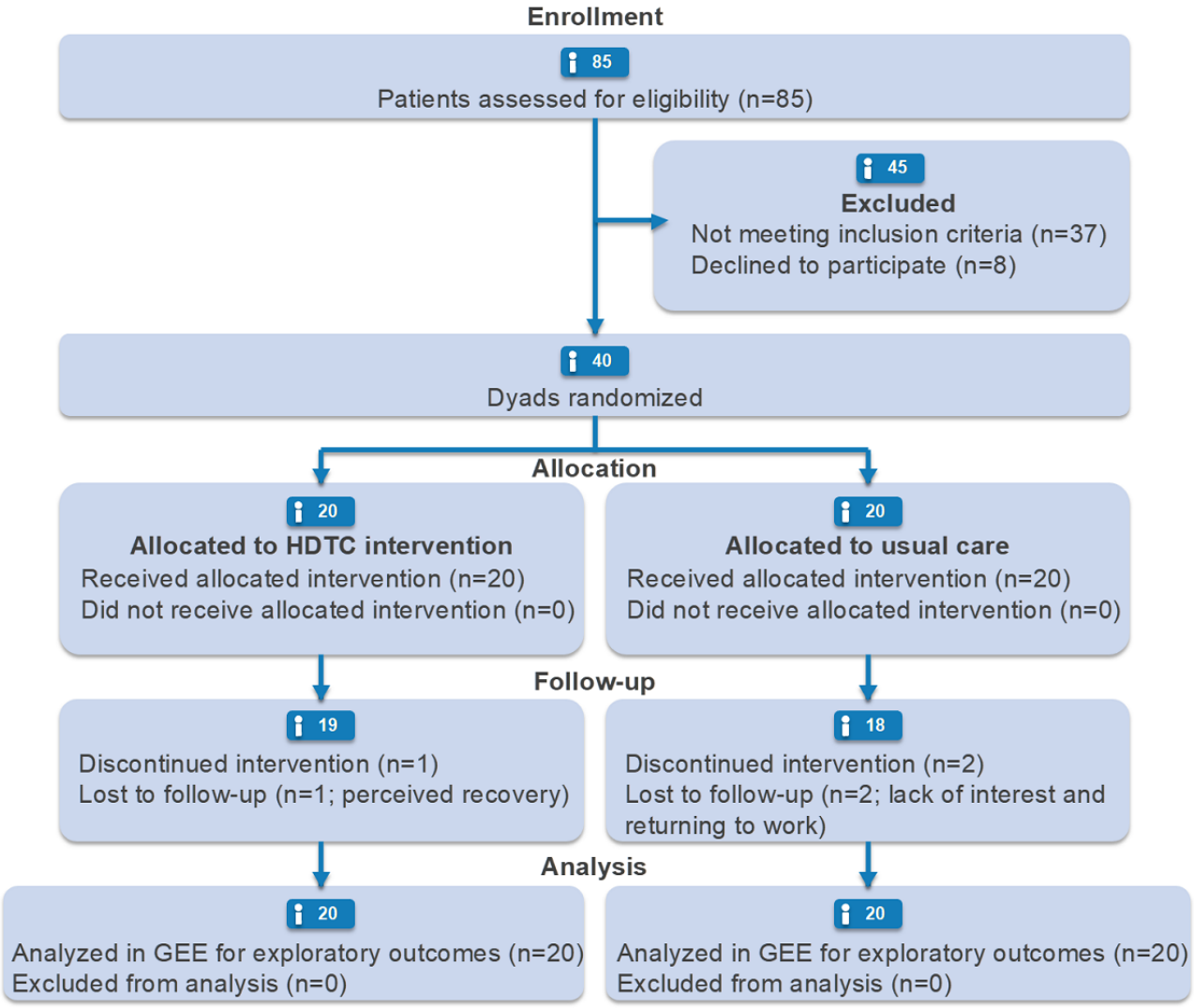
and motivation within the dyad. Together, these digitally enabled components created a supportive and interactive remote environment that effectively extends clinical supervision into the home and enhances both engagement and safety.

Feasibility, Acceptability, and Effects of the Intervention

Baseline Characteristics of the Dyads

The dyads were recruited from a tertiary medical center in Qingdao, China, from October 14 to November 12, 2024. A total of 85 patients (62 online; 23 in person) were referred to this study. During initial screening, 37 patients were excluded. Of the 48 eligible dyads, 8 declined participation due to scheduling conflicts (caregivers: n=4; patients with CHF: n=2) or lack of interest (n=2). The remaining 40 dyads were randomly assigned to the intervention or control group. All dyads completed the 4-week assessment. However, 3 dyads (1 in the intervention group and 2 in the control group) did not complete the 12-week follow-up because of perceived recovery, lack of interest, or returning to work (Figure 3) [51]. No item-level missing data were identified among completed questionnaires. The Little MCAR test was not statistically significant (χ^2_{16}=13.1; *P*=.66), providing no evidence against the MCAR assumption. Baseline characteristics of dyads were comparable between groups (Table 1).

Figure 3. CONSORT (Consolidated Standards of Reporting Trials) 2025 flow diagram of recruitment, randomization, follow-up, and analysis in the pilot randomized controlled trial [51]. GEE: generalized estimating equations; HDTC: home-based, digital-assisted, dyadic tai chi.



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Table 1. Baseline characteristics of patients with chronic heart failure (CHF) and caregivers (N=40).

Characteristics	Total	IG[a] (n=20)	CG[b] (n=20)	χ^2/*t* test	*P* value
Patients with CHF					
Age (y), mean (SD)	61.43 (8.55)	60.65 (9.71)	62.20 (7.39)	0.568[c]	.57
Sex, n (%)				1.129[d]	.29
Male	29 (72.5)	13 (65)	16 (80)		
Female	11 (27.5)	7 (35)	4 (20)		
Educational level, n (%)				0.128[d]	.94
Elementary school	2 (5)	1 (5)	1 (5)		
Secondary school	27 (67.5)	13 (65)	14 (70)		
College or higher	11 (27.5)	6 (30)	5 (25)		
Family monthly income (CN¥; CN¥ 1=US $0.15 as of October 16, 2026), n (%)				2.349[d]	.50
<3000	15 (37.5)	8 (40)	7 (35)		
3000-5000	18 (45)	7 (35)	11 (55)		
5000-10,000	4 (10)	3 (15)	1 (5)		
>10,000	3 (7.5)	2 (10)	1 (5)		
Time since diagnosis (mo), n (%)				1.933[d]	.38
≤6	28 (70)	12 (60)	16 (80)		
6-12	3 (7.5)	2 (10)	1 (5)		
>12	9 (22.5)	6 (30)	3 (15)		
NYHA[e] class, n (%)				1.010[d]	.60
I	12 (30)	7 (35)	5 (25)		
II	13 (32.5)	7 (35)	6 (30)		
III	15 (37.5)	6 (30)	9 (45)		
Etiology of HF[f], n (%)				2.371[g]	.67
Coronary artery disease	30 (75)	14 (70)	16 (80)		
Cardiomyopathies	2 (5)	1 (5)	1 (5)		
Hypertension	21 (52.5)	8 (40)	13 (65)		
Valvular heart disease	6 (15)	4 (20)	2 (10)		
Arrhythmias	7 (17.5)	2 (10)	5 (25)		
Comorbidity types, n (%)				<0.001[d]	>.99
0	4 (10)	2 (10)	2 (10)		
1-2	16 (40)	8 (40)	8 (40)		
≥3	20 (50)	10 (50)	10 (50)		
Caregivers					
Age (y), mean (SD)	54.80 (10.25)	54.15 (9.99)	55.45 (10.71)	0.397[c]	.69
Sex, n (%)				<0.001[d]	>.99
Male	12 (30)	6 (30)	6 (30)		
Female	28 (70)	14 (70)	14 (70)		
Educational level, n (%)				0.451[g]	.80
Elementary school	3 (7.5)	1 (5)	2 (10)		
Secondary school	28 (70)	14 (70)	14 (70)		

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Characteristics	Total	IG[a] (n=20)	CG[b] (n=20)	χ^2/*t* test	*P* value
College or higher	9 (22.5)	5 (25)	4 (20)		
Caregiver type, n (%)				3.584[d]	.06
Spouse	31 (77.5)	18 (90)	13 (65)		
Child	9 (22.5)	2 (10)	7 (35)		
Caring h per d, mean (SD)	3.18 (1.89)	3.20 (1.51)	3.15 (2.25)	−0.082[c]	.94

[a]IG: intervention group.

[b]CG: control group.

[c]Independent *t* test.

[d]Pearson chi-square test.

[e]NYHA: New York Heart Association.

[f]HF: heart failure.

[g]Likelihood ratio.

Feasibility Outcomes

Of the 85 patients referred for screening (average recruitment rate: 2.8 dyads per day; n=85, 100% response rate), 48 were eligible, and 40 dyads were enrolled and randomized, corresponding to a recruitment rate of 83.3% (40/48). Among interested patients (n=85), primary motivators for participation were perceived benefits (68/85, 80%), convenience of home-based delivery (47/85, 55.3%), and insufficient postdiagnosis exercise knowledge (38/85, 44.7%; Table S1 in Multimedia Appendix 4). Retention rates were 100% (40/40) at 4 weeks and 92.5% (37/40) at 12 weeks. Mean attendance to online tai chi classes was 80.6% (SD 14.9%) at 4 weeks and 73.7% (SD 8.6%) at 12 weeks, with 70% (14/20) of participants demonstrating high adherence (≥75% attendance).

Acceptability Outcomes

The detailed responses from the dyadic perspective were shown in Table S2 in Multimedia Appendix 4. Notably, dyads reported positive appraisals of the HDTC intervention. Overall, 100% (20/20) of dyads rated the intervention as acceptable, with 60% (12/20) deeming it completely acceptable.

Safety of the Intervention

During each tai chi class, the dyads' physiological responses were closely monitored and documented by a cardiology nurse. Classes began with warm-up exercises and concluded with cooldown stretches to minimize musculoskeletal injury risk. No intervention-related adverse events were reported during the 12-week intervention, suggesting that it was well tolerated in this pilot sample.

Preliminary Effects of the HDTC Intervention

Effects of the HDTC Intervention for Patients With CHF

Compared to the control group, patients with CHF in the intervention group exhibited significant improvement in 6-minute walk test distance at both 4 weeks (β=12.300, 95% CI 8.733-15.867; *P*<.001) and 12 weeks (β=38.858, 95% CI 15.691-62.025; *P*=.001; Table S3 and Figure S1 in Multimedia Appendix 4). Significant reductions were observed in sedentary time (T1: β=−0.975, 95% CI −1.338 to −0.612; *P*<.001; T2: β=−1.025, 95% CI −1.617 to −0.433; *P*=.01), fear of activity (T1: β=−2.050, 95% CI −3.865 to −0.235; *P*=.03; T2: β=−6.550, 95% CI −11.548 to −1.552; *P*=.01), and Minnesota Living With Heart Failure Questionnaire scores (T2: β=−1.850, 95% CI −3.045 to −0.655; *P*=.002). Effect sizes for these outcomes ranged from moderate to large (Table 2).

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Table 2. Patient, caregiver, and dyadic outcome comparisons at baseline (T0), 4 weeks (T1), and 12 weeks (T2; N=40).

Outcomes and time points	IG[a] (n=20), mean (SD)	CG[b] (n=20), mean (SD)	Effect size, Cohen *d*	*t* test (*df*)	*P* value
Patients with CHF[c]					
6MWT[d] (m)					
T0	415.35 (94.18)	413.70 (81.76)	—[e]	−0.059 (38)	.95
T1	435.95 (93.38)	422.00 (79.80)	0.16	−0.508 (38)	.62
T2	474.16 (75.52)	433.65 (74.50)	0.54	−1.719 (38)	.09
Exercise self-efficacy (0-90)					
T0	41.50 (12.34)	39.95 (13.28)	—	−0.383 (38)	.70
T1	45.00 (10.88)	40.75 (12.13)	0.37	−1.167 (38)	.25
T2	49.45 (10.27)	41.05 (11.61)	0.77	−2.423 (38)	.02
Sedentary time (h)					
T0	9.30 (1.67)	9.40 (1.25)	—	0.215 (38)	.83
T1	8.28 (1.37)	9.35 (1.13)	0.85	2.710 (38)	.01
T2	7.58 (0.80)	8.70 (1.07)	1.18	3.770 (38)	.001
Fear of activity (0-60)					
T0	32.35 (7.85)	32.80 (7.90)	—	0.181 (38)	.86
T1	27.30 (7.80)	29.80 (9.06)	0.30	0.935 (38)	.36
T2	22.50 (8.31)	29.50 (9.74)	0.77	2.370 (38)	.02
MLHFQ[f] (0-105)					
T0	59.05 (9.59)	60.05 (12.14)	—	0.289 (38)	.77
T1	50.85 (10.51)	56.80 (11.98)	0.53	1.670 (38)	.10
T2	40.70 (10.76)	53.05 (11.99)	1.08	3.428 (38)	.001
Mutuality (0-60)					
T0	37.45 (5.87)	37.05 (8.24)	—	−0.177 (38)	.86
T1	43.05 (9.45)	36.95 (7.70)	0.71	−2.239 (38)	.03
T2	48.16 (8.90)	37.25 (7.59)	1.32	−4.124 (38)	<.001
Caregivers					
Care burden (0-88)					
T0	26.35 (7.76)	26.10 (7.69)	—	0.102 (38)	.92
T1	24.25 (7.22)	25.75 (7.89)	0.20	−0.627 (38)	.54
T2	22.60 (6.27)	26.70 (6.45)	0.64	−2.039 (38)	.048
Personal burden (0-48)					
T0	9.50 (3.58)	9.95 (3.14)	—	−0.423 (38)	.68
T1	8.90 (3.11)	9.70 (3.37)	0.25	−0.780 (38)	.44
T2	8.25 (2.40)	9.90 (2.79)	0.63	−2.004 (38)	.05
Role burden (0-36)					
T0	16.85 (5.20)	16.15 (5.39)	—	0.418 (38)	.68
T1	15.35 (5.01)	16.05 (5.34)	0.14	−0.428 (38)	.67
T2	14.35 (4.51)	16.80 (5.00)	0.51	−1.627 (38)	.11
Quality of life (16-80)					
T0	49.75 (6.08)	47.60 (4.56)	—	−1.266 (38)	.21
T1	52.50 (5.52)	49.55 (3.25)	0.60	−2.059 (38)	.048

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Outcomes and time points	IG[a] (n=20), mean (SD)	CG[b] (n=20), mean (SD)	Effect size, Cohen *d*	*t* test (*df*)	*P* value
T2	52.55 (5.03)	49.10 (3.13)	0.82	−2.605 (38)	.01
Mutuality (0-60)					
T0	37.75 (10.28)	37.40 (10.28)	—	−0.109 (38)	.91
T1	42.50 (12.01)	38.30 (9.14)	0.39	−1.245 (38)	.22
T2	44.95 (12.43)	38.20 (7.35)	0.66	−2.090 (38)	.04

[a]IG: intervention group.

[b]CG: control group.

[c]CHF: chronic heart failure.

[d]6MWT: 6-minute walk test.

[e]Not applicable.

[f]MLHFQ: Minnesota Living With Heart Failure Questionnaire.

Effects of the HDTC Intervention for Caregivers

Caregivers in the intervention group demonstrated significant reduction in Zarit Caregiver Burden Interview scores compared to controls at both 4 weeks (β=−1.750, 95% CI −2.499 to −1.001; *P*<.001) and 12 weeks (β=−4.350, 95% CI −5.765 to −2.935; *P*<.001), with effect sizes ranging from small to moderate (Table 2). However, no significant between-group differences were observed in Family Caregiver Quality of Life scores (β=1.300, 95% CI −1.644 to 4.244; *P*=.39; Table S3 and Figure S2 in Multimedia Appendix 4).

Effects of the HDTC Intervention for Dyads

Both patients with CHF and caregivers in the intervention group showed significant improvements in mutuality scores at 4 weeks (patients with CHF: β=5.700, 95% CI 1.126-10.274; *P*=.02; caregivers: β=3.850, 95% CI 1.961-5.739; *P*<.001) and 12 weeks (patients with CHF: β=10.508, 95% CI 5.534-15.482; *P*<.001; caregivers: β=6.450, 95% CI 3.652-9.248; *P*<.001; Table S3 and Figure S3 in Multimedia Appendix 4).

Discussion

Principal Findings

The potential therapeutic benefits of tai chi have been increasingly investigated [52,53], but dyadic tai chi interventions among patients with CHF and their caregivers remain under-studied [13]. This study developed and evaluated an HDTC intervention that engaged patients and caregivers as active participants in a shared rehabilitation process, thereby extending conventional patient-centered exercise toward a dyad-oriented model. The intervention demonstrated satisfactory recruitment, retention, attendance, and acceptability, providing initial evidence that this approach is feasible in the home setting. No intervention-related adverse events were reported during the 12-week intervention, although the small sample size limits conclusions regarding safety. Exploratory analyses also indicated preliminary improvements across patient, caregiver, and dyadic outcomes. However, this study was not powered to establish clinical effectiveness. If confirmed in a fully powered trial, this model may offer a practical strategy for expanding home-based cardiac rehabilitation while addressing the needs of both patients and caregivers.

Feasibility of the HDTC Intervention Among Dyads

The HDTC intervention demonstrated encouraging recruitment, with enrollment completed within 1 month. The overall recruitment rate was 83.3% (40/48), comparable to the 75.1% reported in a previous dyadic study [14]. Although dyadic interventions often face recruitment challenges because of the need to coordinate participation by both members [54,55], recruitment in this study may have been facilitated by multiple recruitment pathways and close collaboration with the Department of Cardiology at the Affiliated Hospital of Qingdao University.

Notably, the relatively low refusal rate may have been due to nurses' extensive experience with patients with CHF [54], stakeholder-informed tailoring of the intervention, and its home-based delivery [56]. Participant feedback also suggested that dyads perceived the intervention as beneficial, and more than half valued the home-based convenience. Feasibility was further supported by complete retention at 4 weeks and a satisfactory retention rate at 12 weeks. Free access, convenient home-based practice, and social support from caregivers and nurses may have contributed to sustained engagement and retention [57]. Mean attendance was consistent with findings from a previous tai chi study [58], while adherence was comparable to that reported in a previous home-based cardiac rehabilitation study (14/20, 70% vs 73%) [59]. Collectively, these findings support the feasibility and acceptability of the HDTC intervention in this pilot setting.

Acceptability of the HDTC Intervention Among Dyads

All dyads in the intervention group rated the HDTC intervention as acceptable, with 60% (12/20) rating it as completely acceptable. This high acceptability may reflect the intervention's dyadic tailoring and home-based delivery, which may also have promoted participant engagement and adherence [60]. Findings align with evidence that tai chi has been reported to be feasible and well tolerated among patients with frailty [61-62]. Its acceptability may have been further enhanced by caregiver involvement, which could provide encouragement and reinforce patients' motivation to engage in regular exercise [63].

Regarding engagement, 45% (9/20) of patients with CHF reported that the intervention required substantial effort, whereas 70% (14/20) of caregivers described it as moderately effortful.

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Informal telephone follow-up suggested that difficulties in learning tai chi forms contributed to the perceived effort, a challenge also reported in previous studies involving older adults [64]. This highlights the need for refinements in a full-scale RCT. Suggested strategies include (1) enhanced instructional support with clearer, more detailed demonstrations; (2) incremental learning of new forms; and (3) pretraining videos coupled with regular review sessions. Together, these approaches aim to ease skill acquisition, foster independent practice, and support long-term retention.

Preliminary Effects of the HDTC Intervention

For patients with CHF, the intervention showed favorable preliminary effects on exercise tolerance, sedentary time, fear of activity, exercise self-efficacy, and health-related QoL, generally consistent with previous evidence on tai chi and home-based rehabilitation [21,49]. These changes may reflect the gradual, low-impact nature of tai chi and the intervention's emphasis on replacing sedentary behavior with structured home exercise, while supervised practice and progressive skill acquisition may also have supported confidence and reduced fear of activity [65,66]. Given the pilot design, these findings should be interpreted as preliminary signals rather than definitive evidence of efficacy.

For caregivers, the intervention was associated with reduced caregiver burden, whereas QoL did not show a significant improvement, possibly because broader QoL is influenced by multiple factors, including caregiving distress and competing social and family demands, and may therefore be less responsive over a short intervention period [13,67,68]. At the dyadic level, both patients and caregivers showed improved mutuality, which may reflect the intervention's emphasis on joint decision-making, shared exercise participation, and mutual encouragement, in contrast to dyadic interventions focused primarily on patient self-care [69]. These findings suggest that dyadic exercise may influence not only individual outcomes but also the relational processes within the patient-caregiver pair.

Strengths and Limitations

A key strength of this study was its explicit focus on dyads of patients with CHF and their caregivers throughout intervention conceptualization, development, and evaluation, addressing an important gap in previous research [13]. The HDTC intervention was developed through an evidence-based approach incorporating a comprehensive literature review, theoretical frameworks, and stakeholder consultation, thereby enhancing its conceptual foundation and contextual relevance.

Several limitations should be considered. First, the pilot sample was small and was not powered for definitive between-group testing of clinical outcomes; consequently, effect estimates are imprecise and exploratory. Second, the 12-week follow-up does not establish whether engagement or outcome changes are sustained after intervention completion. Third, participants were recruited from a single tertiary medical center and through voluntary recruitment pathways, which may limit generalizability to other health care settings and may have preferentially enrolled dyads who were more motivated to exercise or use digital technology. Fourth, requiring both members of the dyad to participate may have further selected families with greater caregiver availability and relational capacity. Fifth, although both patient and caregiver outcomes were measured, the small sample limited the ability to reliably estimate dyadic interdependence. Finally, feasibility estimates such as recruitment and adherence are context dependent and require confirmation in larger, multicenter settings.

Conclusions

The HDTC intervention demonstrated feasibility and acceptability among dyads, with preliminary evidence suggesting potential to improve dyadic health outcomes. These findings support further evaluation of this dyad-oriented, digitally supported home rehabilitation model in a sufficiently powered multicenter RCT with longer follow-up.

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Data Availability

The data that support the findings of this study are available from the corresponding author on reasonable request.

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Generative AI Use

The generative AI tool used was ChatGPT (GPT-6; OpenAI). Responsibility for the final manuscript lies entirely with the authors.

Authors' Contributions

Conceptualization: YZ, FWN, YJX
Formal analysis: YZ
Methodology: YZ, LC, XL, YJX
Project administration: YZ, LC, XL, WZ
Supervision: FWN, WZ, LW, YJX
Validation: YJX
Writing—original draft: YZ
Writing—review and editing: YZ, FWN, LC, LW, YJX

Conflicts of Interest

None declared.

Multimedia Appendix 1

CONSORT-eHEALTH checklist.
[PDF File (Adobe PDF File), 3062 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Interview guide for the focus group interviews.
[DOCX File , 13 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Results of the focus group interviews.
[DOCX File , 22 KB-Multimedia Appendix 3]

Multimedia Appendix 4

Supplementary analyses and longitudinal changes in patient, caregiver, and dyadic outcomes.
[DOCX File , 418 KB-Multimedia Appendix 4]

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Abbreviations

CHF: chronic heart failure
CONSORT: Consolidated Standards of Reporting Trials
HDTC: home-based, digitally assisted, dyadic tai chi
HF: heart failure
MCAR: missing completely at random
QoL: quality of life
RCT: randomized controlled trial

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