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EXPERT OPINION

An Evidence-Based Exercise Program for Total Hip Arthroplasty Rehabilitation in Geriatric Patients with Femoral Neck Fractures: A Delphi Study

Yazhuo Gao[1], Qianyin Zhu[2], Xiaoyan Zhan[3], Fangfang Zhong[1], Yuhan Zhu[1], Wenjia Li[1], Xuehua Zhu[1]

[1]School of Nursing, Zhejiang Chinese Medical University, Hangzhou, Zhejiang Province, People's Republic of China; [2]Department of Nursing, The Second Affiliated Hospital of Zhejiang University School of Medicine, Hangzhou, Zhejiang Province, People's Republic of China; [3]Audit Office, The First Affiliated Hospital of Zhejiang Chinese Medical University (Zhejiang Provincial Hospital of Chinese Medicine), Hangzhou, Zhejiang Province, People's Republic of China

Correspondence: Xuehua Zhu, School of Nursing, Zhejiang Chinese Medical University, No. 548 Binwen Road, Puyan Street, Binjiang District, Hangzhou, Zhejiang Province, 310053, People's Republic of China, Email Snow_zxh@163.com

Background: Femoral neck fractures (FNFs) represent a significant public health challenge in aging populations. Total hip arthroplasty (THA) has emerged as the preferred surgical management for active geriatric patients over 60 years old. However, standardized, evidence-based rehabilitation protocols specifically tailored to the Chinese healthcare context remain limited.

Purpose: This study aimed to develop and validate an expert consensus-based exercise program for geriatric Chinese patients with FNFs undergoing THA, addressing gaps in pre-operative preparation, post-operative care, and home-based rehabilitation continuity.

Patients and Methods: Using the Model for Evidence-Based Practice Change framework, we conducted a multi-phase study: (1) needs assessment through semi-structured interviews with 21 healthcare professionals; (2) systematic evidence synthesis from 16 high-quality sources; and (3) iterative refine the program through two-round Delphi consultation with 15 multidisciplinary experts from orthopedics, rehabilitation medicine, nursing, and management.

Results: The Delphi process demonstrated high expert engagement (response rates: 93.75% round 1, 100% round 2) and acceptable authority (Cr=0.917). Expert coordination improved across rounds, with Kendall's W values increasing from 0.244–0.287 (round 1) to 0.104–0.371 (round 2) for different item levels, and coefficient of variation decreasing from 0.00–0.64 to 0.00–0.14. 11 items with CV>0.25 were eliminated after round 1, reflecting initial variability in expert opinions. The iterative consensus process yielded a four-domain program structure: (1) in-hospital pre-operative rehabilitation, (2) in-hospital post-operative rehabilitation, (3) out-of-hospital home-based rehabilitation, and (4) follow-up care. The final program comprises 4 first-level items, 17 second-level items, and 63 third-level items with specific operational parameters including timing, frequency, intensity, and methods adapted to Chinese clinical practice patterns.

Conclusion: Through rigorous expert consensus methodology, this study developed a comprehensive, multi-level rehabilitation framework for geriatric FNFs patients undergoing THA in China, achieving acceptable agreement on program content and feasibility. As consensus-based findings, prospective validation is essential to establish clinical effectiveness and guide evidence-based implementation.

Keywords: geriatric rehabilitation, exercise program, evidence-based design, Delphi expert consensus method

Introduction

Femoral neck fractures (FNFs) occur at the junction between the femoral head and the base of the femoral neck. The main clinical manifestations are hip pain, swelling, and limb external rotation deformity.[1] In severe cases, they cannot stand or walk, which affects the quality of life.[2,3] In recent years, demographic shifts towards an aging population have

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led to a rise in FNFs incidence, establishing them as a major contributor to loss of independence and mortality among vulnerable geriatric groups, thereby imposing a substantial economic burden on global healthcare systems.[4–6] Treatment options for FNFs vary according to patient age, bone quality, and overall health status. Conservative treatment carries high risks of secondary displacement and serious complications including pressure injuries, pneumonia, and deep vein thrombosis.[7–9] While internal fixation remains appropriate for younger patients (<60 years) and select geriatric cases,[10] total hip arthroplasty (THA) has emerged as the preferred surgical option for active geriatric patients over 60 years.[11] Compared with hemiarthroplasty and internal fixation, THA demonstrates superior outcomes in hip function, post-operative recovery, complication rates, and quality of life, with shorter hospital stays and lower revision rates.[12–14]

Recent data reveal that muscle strength is lost at a rate of 5% per day when patients with fractures are bedridden.[15] The longer the bed rest time, the slower the recovery of muscle strength of FNFs patients and the higher the incidence of post-operative pulmonary infection and delirium, among which the incidence of pulmonary infection can be as high as 17.0%-27.8%.[16] Prior research demonstrates that early muscle strength training and joint range of motion training can prevent muscle and joint disuse, and pulmonary rehabilitation can effectively prevent perioperative pulmonary infection.[17] Pulmonary rehabilitation can effectively prevent perioperative pulmonary infection. Activities such as bed, gait, respiratory, resistance, and aerobic exercise are introduced to accelerate the rehabilitation process of geriatric FNFs patients.[18]

International evidence supports rehabilitation methods including aerobic exercise, resistance exercise, home exercise, and multimodal exercise for geriatric FNFs patients.[19] In contrast, China's current rehabilitation service system still centers around inpatient rehabilitation, home-based care, and hospital-led models.[20] The optimization of rehabilitation tailored to the Chinese medical scenario has not received sufficient attention. This gap is particularly prominent in the field of pulmonary rehabilitation.[21] Despite the established benefits of THA, current rehabilitation protocols for geriatric FNFs patients in China face several critical limitations. First, existing programs predominantly focus on isolated post-operative phases rather than providing comprehensive continuum of care from pre-operative preparation through long-term home-based recovery.[22–24] Second, standardized "one-size-fits-all" approaches fail to address the significant heterogeneity among geriatric patients. Studies indicate that 22.4%–80.7% of geriatric hip fracture patients present with pre-operative frailty,[25] and approximately 31.3% experience cognitive impairments that hinder adherence to rehabilitation instructions.[26] Additionally, kinesiophobia affects 42.92% of geriatric THA patients, leading to reduced engagement in prescribed exercises.[27] Third, current rehabilitation guidelines lack detailed, operationalized protocols that account for the unique characteristics of the Chinese healthcare context, including nurse-to-patient ratios, availability of rehabilitation specialists, and cultural preferences.[28,29] Although rehabilitation processes are standardized, the descriptions remain rather general, making them difficult to replicate and implement across institutions. Furthermore, a systematic and evidence-based intervention system has not been established yet, making it difficult to meet the clinical needs of precise rehabilitation. Fourth, the absence of integrated "hospital-community-home" care systems creates gaps in continuity of care,[30] exacerbating the aforementioned challenges. This is particularly critical given that elderly patients' pain sensitivity and fear of movement can prematurely terminate exercise programs.[31–33] These multifaceted barriers underscore the urgent need for an evidence-based, contextually adapted rehabilitation framework.

Professor Rosswurm and Larrabee from West Virginia University 1999 proposed a model for Evidence-Based Practice Change. This model is based on analysing the theoretical and research literature related to evidence-based practice, evidence application, and change theory and guides practitioners to obtain, interpret, and integrate the best available research evidence, patient data, and clinical observations.[34] It consists of six steps: assess the need for change in practice, link the problem with interventions and outcomes, synthesise the best evidence, design a change in practice, implement and evaluate the practice change, integrate and sustain change and maintain the changes in practice. This model emphasises that clinical practitioners should find problems in time, standardise the translation of evidence-based evidence into clinical change measures, and combine specific clinical scenarios and research evidence to optimise patient care quality and ensure evidence transformation's scientific approach and effectiveness.[35]

Based on the above, we hypothesised that an effective exercise-based rehabilitation model for geriatric FNFs patients following THA should address several key factors: (1) optimal rehabilitation setting selection; (2) comprehensive exercise components including progressive resistance training, range of motion exercises, functional ambulation training,

and balance training; (3) appropriate timing and frequency of intervention; (4) patient-specific considerations such as cognitive function, pre-fracture functional status, and psychosocial support; (5) multidisciplinary team coordination. At present, relevant studies at home and abroad show that the evidence resources in the field of THA rehabilitation for geriatric FNFs patients are increasing. Recent study by Freitas et al supports this hypothesis, demonstrating that rehabilitation leads to significant functional recovery regardless of setting, with outpatient and home-based programs showing particularly favorable outcomes.[36] The evidence-based practice change model is conducive to strengthening the relationship between researchers and practitioners, providing feedback and improvement, and carrying out practice change to promote the rapid transformation of evidence and optimising resources.

This study aims to construct a systematic, scientific and effective THA exercise program for geriatric FNFs patients by integrating the best available evidence, clinical expertise, and patient preferences within the evidence-based practice change framework. We will test our hypothesis by synthesising current evidence, designing a multicomponent rehabilitation protocol that addresses these critical factors.

Materials and Methods

Study Design

The development process was guided by the Model for Evidence-Based Practice Change and comprised four key phases: (1) a needs assessment conducted through semi-structured interviews with healthcare providers; (2) a systematic synthesis of current evidence; (3) initial program development based on the assessment and evidence; and (4) iterative refinement of the program through a two-round Delphi expert consultation.

Establish a Research Group

There are seven members in the research group, including one Associate Professor, two nurses-in-charge, one rehabilitation therapist, and three postgraduate students. All group members have received systematic education and training in evidence-based medicine, ensuring strong methodological competence. The team comprises an Associate Professor with extensive experience in clinical research and scientific research, Supervisor Nurses with advanced clinical expertise and specialized knowledge in patient care, and a Rehabilitation Therapist with professional certification and rich practical experience. The postgraduate students possess specialized training in systematic review methodology, literature search strategies, critical appraisal, and quantitative analysis. This multidisciplinary composition combines clinical expertise with research proficiency, ensuring comprehensive perspectives and rigorous methodology in evidence synthesis and guideline formulation.

Preliminary Construction of the Intervention Program

Semi-Structured Interviews

A purpose sampling method was used to select 21 clinical medical staff in a tertiary hospital in Zhejiang, including six orthopedic surgeons responsible for orthopedic surgeries, five rehabilitation therapists responsible for sports guidance, and ten nurses responsible for inpatient care. The inclusion criteria of the respondents were: ① Voluntarily participating in the interview; ② Ability to effectively communicate in written and spoken Chinese, as all consultations were conducted in Chinese. Experts needed to be able to clearly articulate their professional opinions and rationale in the consultation questionnaires; ③ Five years or more professional work experience and the experience of treating or caring for geriatric FNFs patients; ④ Professional title is intermediate or above. Exclusion criteria were: ① Off-duty during the study period for any reason, such as sick leave, maternity leave, study abroad, business trips, and rural services; ② Non-hospital in-service medical staff, such as interns, standardised trainees, and other trainees. Two additional individuals were interviewed following data repetition, and no new themes emerged during data analysis, thereby confirming sample saturation. This approach adheres to the principles outlined in the qualitative research literature cited above.[37] All medical staff members consented to participate in the interview, and none withdrew during the process.

The interview guide was developed through a systematic and iterative process to ensure content validity. First, a comprehensive literature review was conducted to identify core themes.[38–41] Second, the preliminary version of the

guide was reviewed by four clinical experts specializing in geriatric orthopedic rehabilitation to evaluate its relevance, clarity, and clinical applicability. Third, pilot interviews were conducted with three experienced healthcare professionals to assess question comprehensibility and their effectiveness in eliciting detailed and meaningful responses; this phase informed refinements in wording, sequencing, and overall logical flow. Finally, the research team conducted iterative discussions to review feedback and finalize the interview guide, ensuring methodological rigor and alignment with study objectives. The interview guide was as follows: ① According to your clinical work experience, how do geriatric patients with FNFs cope with rehabilitation? ② How do you guide patients to perform daily rehabilitation during work? ③What problems do you think exist for current medical staff when guiding patients to perform rehabilitation? How can they be solved? ④ What factors do you think will affect patient compliance with rehabilitation? ⑤ What factors affect communication and cooperation among multidisciplinary team members? ⑥ What are your opinions and suggestions on rehabilitation for geriatric patients with FNFs? The Semi-Structured Interview Questionnaire Guide is provided in Supplementary Material 1. A descriptive qualitative research method was used, and data collection and analysis were undertaken simultaneously. The recording was transcribed within 24 hours of the interview. The qualitative analysis software QSR NVivo 12 was used to encode, identify, and summarise non-numerical data (such as the interviews and audio).[42] The content analysis method was used to analyse, collate, and summarise data.[43] The demographic data of the respondents were analysed using descriptive statistics.

Summary of Best Evidence

Identify Evidence-Based Questions

PIPOST model was used to construct evidence-based questions:[44] ① P: population is geriatric FNFs patients undergoing THA; ② I: intervention strategies associated with rehabilitative exercises, including resistance exercise, strength training, aerobic exercise, gait training, balance training and so on; ③ P: professionals include medical staff, patients and their family members; ④ O: outcome includes the change of muscle strength, muscle quality, or physical function; ⑤ S: setting of evidence includes hospitals, nursing homes, communities, and families; ⑥ T: type of evidence includes guideline, expert consensus, clinical decision, best evidence summary, systematic review, meta-analysis, and randomised controlled trial data.

Literature Search Strategy

Utilising the English search terms “femoral neck fractures”, “total hip arthroplasty”, “geriatric patients”, and “exercise”, the researcher employed a combination of thematic keywords and free-text queries for the literature search. According to the 6S model of evidence resources, UpToDate, BMJ Best Practice database, WHO, JBI, NICE, GIN, SIGN, NGC, RNAO, AAOS, ASBMR, ESTES, ANZHFR, CSP, Evidence-Based Health Care Center Database, Chinese Medlive Network, Orthopaedic Website, the Cochrane Library, China National Knowledge Infrastructure, Wanfang Database, VIP database, China Biology Medicine Disc, CINAHL, Embase, PubMed, Web of Science. The search time limit was from establishing the database to December 6, 2023. Two reviewers used the Appraisal of Guidelines for Research and Evaluation Instrument (AGREEII) to evaluate the quality of the guidelines independently.[45] The included evidence summary was evaluated using traceback to the original literature, and the corresponding evaluation tools recommended by the Australian JBI Evidence-Based Health Care Center in 2016 were used for systematic reviews and Meta-analysis.

Delphi Expert Consultation

Design of the Inquiry Questionnaire

The questionnaire comprises four parts: ① Letter to experts and instructions; ② The items of intervention program at all levels: experts scored the importance and feasibility of the items using a 5-point Likert scoring method, and “not important” or “not feasible” was 1 point, “very important” or “very feasible” being 5 points. A modification/supplementary comment column was set up, and experts could put forward corresponding deletion or modification suggestions; ③ The basic situation and general information of the experts; ④ Experts’ familiarity with the contents of the letter consultation and their judgment based on the questionnaire.

Experts Selection Criteria

According to the Delphi criteria for selecting experts for correspondence consultation[46] and combined with the needs of this study, 16 experts were expected to participate in this consultation. All 16 experts are professionals in orthopedics and rehabilitation, with rich relevant knowledge reserves, and clinical experience in treatment and rehabilitation. They can provide scientific and systematic guidance and evaluation for the intervention program and professional suggestions for further program improvement. The inclusion criteria for experts in this study were: ① Bachelor degree or above, and intermediate professional title or above; ② Engaged in orthopedic medicine/rehabilitation medicine/orthopedic nursing/rehabilitation nursing/nursing management and other related work for five years or more; ③ Informed consent and willingness to participate in expert consultation.

Implementation of Expert Consultation

Two rounds of expert consultation were conducted, and the questionnaires were distributed in paper or electronic form. After the first round of consultation, the data were analysed and organised. The three indicators of importance, a score>3.5, coefficient of variation (CV)<0.25 and full score ratio>20%, were used as the screening criteria. The CV was calculated as the ratio of standard deviation to mean (CV=SD/Mean), which reflects the degree of dispersion and consistency among expert opinions. The consultation results and expert opinions were integrated and revised after discussion within the research group to form the second questionnaire round. The consultation was conducted again, with an interval between the two consultations of 30 days.

Quality Control

The consultations involved orthopedics, rehabilitation, nursing and other fields. Therefore, no less than two people in each field were selected who were familiar with the study content and had rich work experience to ensure a comprehensive and representative consultation. The questionnaires returned by the experts were carefully checked, and three research team members independently read and analysed the data. The expert opinions were then discussed, and each protocol item was added or modified based on the research purpose and literature support.

Statistical Methods

Excel 2016 and SPSS25.0 were used for statistical analysis. Normality of quantitative data was assessed using the Shapiro–Wilk test, data conforming to normal distribution were expressed as mean±standard deviation ($\overline{x} \pm s$), and qualitative data were expressed as frequency and percentage (%). The authority of experts is expressed by the authority coefficient (Cr), where the Cr=(Ca+Cs)/2. Cr refers to the Authority Coefficient indicating the overall authority level of experts ranging from 0 to 1, Ca refers to the Judgment Basis Coefficient reflecting the foundation on which experts make their judgments including theoretical analysis, practical experience, literature references, and intuitive understanding, and Cs refers to the Familiarity Coefficient indicating the degree of familiarity experts have with the evaluated items. The coordination degree of experts was expressed by the mean and CV of the importance assignment of each item in the scheme. Kendall's W coefficient was used to evaluate the degree of consensus among experts on the importance of each program item, where higher values indicate stronger consensus (W values of 0.3–0.5 indicating moderate consensus, >0.5 indicating strong consensus), and statistical significance was tested using chi-square approximation (P<0.05).

Results

Results of Semi-Structured Interviews

The respondents in this study included eight males and 13 females, aged between 28 and 54 years, with an average age of 38.10 ± 7.71 years. Clinical experience ranged from 5 to 26 years, averaging 11.38 ± 7.43 years. Following a qualitative data analysis, the interview content could be summarised into two themes and six sub-themes. (1) The implementation of rehabilitation faces multiple obstacles: ① Patient initiatives during rehabilitation are insufficient; ② The uncertainty of the comprehensiveness and continuity of rehabilitation, and ③ Textbook theory and clinical practice are not entirely unified. (2) Medical staff's scientific cognition of rehabilitation: ① The necessary professional quality of medical staff;

② Personnel allocation, organisation, and management requiring optimisation, and ③ Implementation of rehabilitation requires multifaceted support.

Summary of the Best Evidence

After literature screening and quality evaluation, 16 articles were assessed, including five guidelines,[47–51] two expert consensus,[52,53] four recommendations,[54–57] one evidence summary,[58] 2 Meta-analysis[59,60] and two systematic reviews.[61,62] Among the five guidelines, four were rated as A level[48–51] of recommendation, and one was rated as B level.[47] The quality of the guidelines was high, so all were included. The quality evaluation of 2 expert consensuses[52,53] and four recommendations[54–57] included were rated as "no" except for the item "whether the viewpoints presented are inconsistent with previous literature". The balance of the items was rated as "yes", indicating that the quality of the literature was high and so was included. A guideline was derived by tracing the original literature summarised in the evidence,[58] which coincided with the included guideline and was subsequently incorporated. All items in the meta-analysis by Lee et al[59] were "yes", and all items in the Meta-analysis by Zhang et al[60] were "yes" except for item ④, which was "unclear". The overall quality of the two articles was high, and they were included. Fairhall et al's study[61] scored "yes" for all items, and Cheatham et al's study[62] scored "yes" except for item ④, which was "unclear", and items ⑩ and ⑪, which were "no".

Results of Delphi Expert Consultation

Demographics of Experts

This study included 15 experts in orthopedic medicine, rehabilitation medicine, orthopedic nursing, rehabilitation nursing, nursing management and other fields for consultation, aged between 34 and 46 years, with an average age of 38.80±4.23 years. Clinical working experience ranged from 8 to 24 years, averaging 14.87±5.26 years. The rest of the general information is shown in Table 1.

Table 1 Demographic Characteristics of Experts (n=15)

Variable		Frequency	%
Gender	Male	6	40.00
	Female	9	60.00
Age (years)	30–< 40	8	53.33
	40–50	7	46.67
Working years (years)	5–< 15	8	53.33
	15–25	7	46.67
Standard of culture	Bachelor	5	33.33
	Master	7	46.67
	Doctor	3	20.00
Professional title	Lecturer	2	13.33
	Associate Professor	2	13.33
	Nurse-in-charge	4	26.67
	Associate chief nurse	1	6.67
	Technologist-in-charge	2	13.33
	Associate chief physician	4	26.67
Areas of expertise	Orthopedic medicine	3	20.00
	Rehabilitation medicine	3	20.00
	Orthopedic care	4	26.67
	Rehabilitation care	3	20.00
	Nursing management	2	13.33

Analysis of Experts Positivity

Two rounds of Delphi expert consultation were conducted in this study. In the first round, 16 copies were distributed, and 15 copies were recovered, with a recovery rate of 93.75%. In the second round, 15 copies were distributed, and 15 copies were recovered, with a recovery rate of 100%, indicating a high expert positivity.

Analysis of Experts Authority

The experts of the two rounds of consultation were the same, and the Ca and Cs of the consultation were 0.94 and 0.89, respectively. Therefore, the Cr of the consultation was 0.92, indicating that the expert authority was high and the results were reliable.

Analysis of Experts' Coordination Degree

CV evaluated the coordination of a single indicator. In the first round of consultation, the coefficient of variation of items was 0.00–0.64, of which 11 items were more substantial than 0.25, and the research team deleted the items. The variation coefficient in the second consultation round was 0.00–0.14, all less than 0.25. In the first round of expert consultation, Kendall's W values of the importance of first-level, second, and third-level items were 0.244, 0.241, and 0.287, respectively. In the second round of expert consultation, Kendall's W values of the importance of first-level, second, and third-level items were 0.371, 0.300 and 0.104, respectively. The Kendall's *W*-test of coordination of the two rounds of expert letter consultation is statistically significant ($P<0.01$), indicating that the expert opinions are relatively concentrated and the coordination is good.

Amendment and Adjustment of Items in the First Round

Recommendations on Items Deletion

Eight experts suggested deleting the position conversion, walking training with a walking aid and the intensity of pre-operative muscle strength training in pre-operative rehabilitation for geriatric FNFs patients. Three experts suggested deleting the time, frequency and intensity of aerobic and endurance training in post-operative rehabilitation. At the same time, the mean value of importance assignment of the above items was<3.5, and the CV was>0.25, which was adopted after discussion by the research group.

Recommendations for Items to Be Added

Three experts emphasised the importance of adhering to the evaluation principle before rehabilitation and added an enhanced assessment of post-operative rehabilitation. Additionally, two experts highlighted the necessity of educating patients and their families about home rehabilitation three days before discharge. Furthermore, three experts recommended increasing training focused on activities of daily living within home exercise programs. Lastly, two experts suggested that follow-up duration and frequency should be differentiated based on whether the approach is online or offline. All recommendations were adopted following discussions by the research group.

Recommendations for Items Modification

Four experts expressed that the temporal distinction between post-operative and home-based rehabilitation was ambiguous and prone to confusion. Consequently, the first-level items were revised to "in-hospital pre-operative rehabilitation", "in-hospital post-operative rehabilitation", and "out-of-hospital home-based rehabilitation". Six experts suggested that the pre-operative "joint activity exercise" should be changed to "joint activity and muscle strength exercise", and the exercise content should be changed to "ankle pump exercise, static contraction training of hip abductor, quadriceps and hamstring muscle, active activity and muscle strength exercises of each joint of the upper limbs and healthy lower limb". The corresponding rehabilitation time and frequency should also be changed accordingly. The exercise content of recumbent training was changed to "supine position, abduction neutral position, hip lifting to prevent stress injury". Two experts suggested that the post-operative "muscle strength, gait, and joint activity exercise" should be refined into three items: "joint activity exercise", "muscle strength exercise", and "position transfer and gait exercise". Three experts pointed out that the intensity of post-operative weight-bearing exercise could not be too precise due to medical and human resources limitations. They recommended that it be changed to "according to the principle of individualisation,

the intensity of weight-bearing should be the Visual Analogue Scale (VAS) score of the affected limb≤3, and it is recommended that the initial weight bearing should be the weight of the limb itself. Gradually increase the weight bearing to full weight. (100% of body weight)". Two experts noted that geriatric patients often present with multiple underlying health conditions, which may prevent them from meeting the established discharge criteria. They recommended utilising the "Post Total Hip Replacement Discharge Scoring Scale (PTHRDSS)" as an adjunctive assessment tool. Two experts suggested that "gradually carry out car driving, bicycle riding, swimming and other activities at 6–8 weeks after operation" should be replaced by "gradually carry out bicycle riding (need to adjust the seat, hip flexion<90°), swimming and other activities at eight weeks after operation". Three experts suggested that online follow-up should delete Email follow-up and add remote follow-up. Four experts suggested adding "medication use and rehabilitation compliance, including important information such as medication dosage, course of treatment, and completion of rehabilitation" and "guidance on activities of daily living and individualised health education" to the follow-up content. All of the recommendations discussed above were adopted.

Amendment and Adjustment of Items in the Second Round

Recommendations for Addition of Items

One expert pointed out that post-operative rehabilitation evaluation and exercise timing items should be separated. The items were adopted after the research group had discussed them.

Recommendations for Modifying Items

Two experts suggested that the pre-operative evaluation need not introduce the specific analgesic treatment, and suggested adjusting the content to "pain assessment should be completed within 2 hours after admission". One expert suggested that "risk assessment of falling bed" should be revised to "risk assessment of falling bed and VTE". Additionally, they suggested that "risk assessment of pressure ulcer" should be revised to "assessment of post-operative muscle strength, risk assessment of pressure ulcer, fall and prosthesis dislocation". Pre-operative recumbent training exercise should be added to the "turning over position exercise", and the training time and frequency should be revised to "one time per group, one group every two hours". Experts also proposed that the intensity of rehabilitation should be increased by "recommending the use of pain group-labeled assessment tool FAS, grade A and B to continue rehabilitation, and grade C to stop exercise" to reduce the subjectivity of the program. Two experts suggested that "strength and stretching exercise" should be revised to "stretching exercise". Two experts suggested that "lifting the pelvis while clamping the ball" should be revised to "keeping the hip in a neutral position while clamping the ball to prevent internal rotation of the hip", "each muscle group" should be changed to "quadriceps femoris, gluteus maximus, gluteus medius and other key muscle groups", and the content of position transfer exercise should be added to "monitor blood pressure while getting out of bed for the first time to prevent orthostatic hypotension". One expert proposed that the "straight leg raising motion" in resistance training of home rehabilitation should be revised to "supine leg raising exercise".

After two rounds of expert consultation and discussion, modification and improvement by group members, the final THA exercise program for geriatric FNFs patients includes four first-level items, 17 second and 63 third-level items. See Table 2 for details.

Discussion

This study successfully developed a systematic, evidence-based exercise program for geriatric Chinese FNFs patients undergoing THA, validated through rigorous expert consensus and addresses three critical gaps in current Chinese clinical practice. First, 4 first-level items directly addresses the fragmented care identified in our semi-structured interviews with 21 clinical personnel. Unlike existing Chinese protocols that focus predominantly on post-operative phases,[24–26] our program establishes continuity from admission through long-term recovery. The strong expert consensus validates the clinical necessity of whole-course rehabilitation, particularly pre-operative optimization, the phase notably absent in current Chinese protocols yet critical for geriatric patients with multiple comorbidities. Second, the program provides 63 detailed third-level items with precise operational parameters (eg, timing: "within 24 hours post-

Table 2 Evidence-Based Exercise Program for Total Hip Arthroplasty Rehabilitation in Geriatric Patients with Femoral Neck Fractures (Final Version)

Items	Importance Assignment ($\bar{x} \pm s$)	CV
A. In-hospital pre-operative rehabilitation	4.80±0.41	0.09
A1. Pre-operative comprehensive rehabilitation evaluation	4.87±0.35	0.07
A1.1. It is recommended that a multidisciplinary team comprising orthopedic surgeons, anesthesiologists, orthopedic and/or rehabilitation nurses, rehabilitation therapists, dietitians, and clinical pharmacologists be established. The assessment should encompass both pre- and post-fracture capabilities in performing daily activities, as well as evaluations of physical condition, mental health status, and the availability of family and social support. The timing of interventions by the multidisciplinary team should be tailored according to the severity of the patient's condition	5.00±0.00	0.00
A1.2. Pain assessment should be completed within 2 hours after admission	4.87±0.35	0.07
A1.3. The muscle strength of the limbs was evaluated and graded. The maximum muscle strength of the limbs in flexion and extension was measured when the patient was lying flat. The range of motion (ROM) of patients was evaluated	4.80±0.56	0.12
A1.4. Evaluate the skin and soft tissue of the operation area, the affected limb's vascular function, and the function of important organs such as the heart, lung, liver, and kidney.	4.87±0.35	0.07
A1.5. Within 24 hours after admission, risk assessment of falling bed, VTE, food, fluid and nutrition assessment, and pressure injury risk assessment were performed	4.80±0.41	0.09
A2. Pre-operative rehabilitation methods	4.80±0.41	0.09
A2.1. Respiratory exercise is recommended, encompassing regular percussion on the back to facilitate phlegm clearance, regular turning over, lip contraction breathing, abdominal breathing, and resistance training of respiratory muscle. (The patient takes a healthy lateral position, the nurse places both hands on the patient's outer chest, does not exert resistance when the patient inhales, and gives both hands an appropriate, balanced and gradually inward force until the expiratory process is terminated. Encourage the patient to try to inhale to the position of maximum movement in the chest)	4.80±0.41	0.09
A2.2. Joint activity and muscle strength exercises are recommended, including ankle pump exercise, static contraction training of hip abductor, quadriceps and hamstring muscle, active activity and muscle strength exercises of each joint of the upper limbs and healthy lower limb	4.80±0.41	0.09
A2.3. Recumbent exercise is recommended, including supine position, abduction neutral position, hip lifting to prevent stress injury and turning over position exercise	4.60±0.63	0.14
A3. Duration and frequency of pre-operative rehabilitation	4.73±0.59	0.13
A3.1. Respiratory exercise: on the initial day of admission, patients engaged in lip contraction breathing, abdominal breathing, and resistance training of respiratory muscle without delay, 10min/ group, two groups/day	4.73±0.46	0.10
A3.2. Joint activity and muscle strength exercise: ankle pump exercise (dorsiflexion and plantar flexion once) was performed immediately on the first day of admission, 10s/time, 10–15 times/group, 1 group/hour; The rest of each movement was repeated ten times, three groups/day	4.80±0.41	0.09
A3.3. Recumbent exercise: on the first day of admission, each movement was performed once/group, and a group was performed every 2 hours	4.53±0.64	0.14
A4. Intensity of post-operative rehabilitation	4.73±0.59	0.13
A4.1. All pre-operative exercises should be promptly discontinued upon the onset of fatigue and/or pain. The Functional Activity Score (FAS) is recommended for evaluating pain levels. Rehabilitation should be maintained for grades A and B, while they should be halted for grade C	4.67±0.62	0.13
A5. Pre-operative rehabilitation health education and consultation	4.87±0.35	0.07
A5.1. Provide oral and written information about treatment and care to patients (or their caregivers and/or family members, as appropriate), including the medical diagnosis, choice of anesthesia, choice of analgesics and other medications, surgical procedures, possible complications (such as venous thromboembolism, incision infection, loosening or dislocation of joints), post-operative care, rehabilitation protocols, health professionals involved	4.80±0.41	0.09

(*Continued*)

Table 2 (Continued).

Items	Importance Assignment ($\bar{x} \pm s$)	CV
A5.2. Providing patients and their families with nutritional guidance, as well as strategies for managing activities of daily living; facilitating the use of adaptive equipment, such as walkers for standing and ambulation; offering recommendations on movements to avoid, including improper lifting and carrying postures, as well as techniques for washing and bathing; instructing patients in post-operative rehabilitation and essential activities like bowel and bladder training in bed, bed mobility, transitioning from lying down to sitting up or getting out of bed, utilising the toilet and sitting in a chair	4.80±0.41	0.09
A5.3. Patients are advised to refrain from smoking and alcohol consumption, as well as to enhance their dietary habits prior to surgery	4.80±0.41	0.09
A5.4. It is advisable to promptly identify and address correctable comorbidities prior to surgery, including anemia, anticoagulation issues, electrolyte imbalances, acute diabetic complications, uncontrolled heart failure, reversible arrhythmias or ischemia, and sepsis resulting from pulmonary infections	4.87±0.35	0.07
A5.5. It is recommended that suitable psychological interventions be implemented for patients, complemented by anti-anxiety medications, sleep aids, and other pharmacological treatments as necessary to address negative psychological states, regulate emotions, and enhance sleep quality	4.73±0.46	0.10
B. In-hospital post-operative rehabilitation	5.00±0.00	0.00
B1. Comprehensive post-operative rehabilitation evaluation	5.00±0.00	0.00
B1.1. It is recommended to conduct a comprehensive risk assessment for deep vein thrombosis and pulmonary embolism, along with the continuous assessment of post-operative muscle strength, risk assessment of pressure ulcer, fall and prosthesis dislocation, corresponding cognitive function assessment, and regular monitoring of nutritional status and pain management during hospitalisation	5.00±0.00	0.00
B2. Timing of post-operative rehabilitation	5.00±0.00	0.00
B2.1. Patients should begin to sit up and ambulate as soon as feasible following surgery. Rehabilitation should be initiated under the supervision of a rehabilitation physician or therapist within 24 hours postoperatively, unless contraindicated by medical or surgical considerations. When cardiopulmonary function and overall condition allow, patients may be encouraged to engage in standing weight-bearing exercises and ambulation exercises after surgery	5.00±0.00	0.00
B3. Post-operative rehabilitation methods	5.00±0.00	0.00
B3.1. Respiratory exercise is recommended, encompassing regular percussion on the back to facilitate phlegm clearance, regular turning over, lip contraction breathing, abdominal breathing, and resistance training of respiratory muscle. It is recommended to assist expiratory and inspiratory muscles with breathing adjustment exercises while performing ankle pump exercises, upper limb stretching exercises and flexibility exercises, quadriceps femoris isometric contraction and other functional exercises	4.93±0.26	0.05
B3.2. Joint activity exercise is recommended, including ankle pump exercises, hip and knee extension exercises (hip and knee flexion on the healthy side, active extension on the affected side), heel sliding and hip and knee flexion exercises (starting at 45° and gradually increasing the range of motion, preventing hip flexion beyond 90° while lying down, sitting, or bending forward; Prevention of hip adduction and internal rotation), hip abduction training (supine position with mild hip abduction of 20°-30° on the affected side without hip rotation)	4.93±0.26	0.05
B3.3. Muscle strength exercise is recommended, including early training of both upper limbs and lower limbs of the healthy side, hip abductor strength training, and appropriate muscle strength training around the hip, including isometric contraction of quadriceps femoris, gluteus maximus, gluteus medius, and hamstrings	4.93±0.26	0.05
B3.4. Resistance exercise is recommended by strapping a 1kg sandbag to the affected lower leg to train the hip flexor group (45°-60°), hip adductor group (to neutral position), hip abductor group, and hip posterior extensor group	4.73±0.59	0.13
B3.5. Position transfer and gait exercises are recommended, including bed-sit-to-bedside sit-to-stand, bed-sit-to-stand, and stand-to-walk (no thigh or knee crossing, no hip or thigh rotation, upper body and lower limb Angle>90°, no hip flexion more than 90° and no turning the body to the affected side when standing). Also, perform stepping in the same place (feet shoulder-width apart, standing on your toes while bending and extending your hips and knees, standing on one leg while slowly swinging the other back and forth, and finally alternating the two legs repeatedly, stepping up and down).	4.93±0.26	0.05

(*Continued*)

Table 2 (Continued).

Items	Importance Assignment ($\bar{x} \pm s$)	CV
B3.6. For people without severe osteoporosis, it is recommended to start weight-bearing exercise with an assistive device (such as a walker). When the patient is in the supine position, the abdominal muscles, gluteal muscles, hamstrings, and quadriceps muscles are first activated by placing a ball between the bent knees with the legs flexed and the feet under the balance pad, keeping the hip in a neutral position while clamping the ball to prevent internal rotation of the hip. When the patient was standing, the affected limb was first moved in different directions, forward and backward, left and right, and slowly loaded, and then gradually received two-handed standing with a walking aid (no weight bearing on the affected limb), two-handed standing with a walking aid (half weight bearing on the affected limb), and two-handed walking with a walking aid (full weight bearing on the affected limb)	4.87±0.35	0.07
B3.7. Balance and proprioceptive exercises are recommended, including standing by single leg (patients at high risk for falls use an aid, with the healthy arm standing and the affected arm lifting and attempting to remove the aid), half-squat knee-flexion training, standing with the eyes open and closed, and walking in a straight line while changing speed and direction	4.47±0.64	0.14
B4. Duration and frequency of pre-operative rehabilitation	5.00±0.00	0.00
B4.1. Respiratory exercise: it is recommended to perform lip retraction breathing, abdominal breathing, and respiratory muscle resistance training within 24 hours after surgery, 10min/ group, two groups/day, and continue until discharge	4.80±0.41	0.09
B4.2. Joint activity exercise: it is recommended to perform ankle pump exercise (dorsiflexion and plantar flexion once) after the disappearance of anesthesia, 10s/time, 10–15 times/group, 1 group/hour; Hip and knee extension, flexion and abduction training each action 10s/ time, ten times per group, at least two groups/day (hip and knee flexion training in the supine position within one week, hip and knee activities in all directions in the standing position after one week), continued until discharge	4.93±0.26	0.05
B4.3. Muscle strength exercise: starting quadriceps femoris, gluteus maximus, and gluteus medius isometric contraction exercises on the first day after the operation are recommended. The contraction should last for 5s, and the relaxation for 5s was one time, ten times/group, and three groups/day. The rest of the exercises were recommended for 10s/time, ten times/group, three groups/day, and continued until discharge	4.93±0.26	0.05
B4.4. Resistance exercise: it is recommended to exercise quadriceps femoris, gluteus maximus, gluteus medius and other key muscle groups, 10–15 times/group from the first day after surgery, two groups/day until discharge	4.73±0.59	0.13
B4.5. Position transfer and gait exercise: it is recommended to assess the patient without obvious pain and discomfort within 24 hours after surgery, raise the head of the bed to 60° and ask him to maintain the sitting position for 5 minutes, then transfer to the bedside sitting position, sit and stand for 5 minutes, and then transfer the bedside sitting position to standing position. The affected limb gradually contacts the ground and stands for 5 minutes with the help of a walking aid (monitor blood pressure while getting out of bed for the first time to prevent orthostatic hypotension). The training of stepping into the same place started from the fifth day after the operation, 10 minutes each time, twice a day	4.93±0.26	0.05
B4.6. Weight-bearing exercise: It is recommended that patients use the walking aid for lower limb training within 24 to 48 hours after surgery. The walking distance is 5 to 10 meters on the first day after surgery and can be doubled on the second day. According to the individual's tolerance, the frequency of weight-bearing is gradually increased from 10min/d to 20min/ day, and from two times/day to four times/day. It is advisable to increase weight-bearing activities after 1 to 2 weeks progressively, discontinue the use of walkers by 4 to 5 weeks, and achieve full weight-bearing within 6 to 8 weeks	4.87±0.35	0.07
B4.7. Balance and proprioceptive exercise: 20–30 minutes per time, twice a day, is recommended starting on the fifth post-operative day (including warm-up and rest periods)	4.53±0.64	0.14
B5. Intensity of post-operative rehabilitation	5.00±0.00	0.00
B5.1. Weight-bearing exercise: according to the principle of individualisation, the intensity of weight-bearing should be the Visual Analogue Scale (VAS) score of the affected limb≤3, and it is recommended that the initial weight bearing should be the weight of the limb itself. Gradually increase the weight bearing to full weight (100% of body weight)	4.80±0.41	0.09

(*Continued*)

Table 2 (Continued).

Items	Importance Assignment ($\bar{x} \pm s$)	CV
B5.2. Muscle strength exercise: based on RPE (score range 6–20, > 13 points indicate obvious respiratory and fatigue symptoms, ≥17 points need to stop exercise, its value is multiplied by 10 to close to the heart rate level of the loading person), moderate to high-intensity resistance exercise of the main muscle groups of the lower limbs is recommended. Moderate to high-intensity resistance exercise is recommended for four muscle groups (leg press, hip abduction, hip extension, and heel elevation) with a maximum of 8 repetitions and a maximum of 3 times. Reassess strength every two weeks.	4.80±0.41	0.09
B5.3. The rest of the post-operative exercises should be promptly discontinued upon the onset of fatigue and/or pain. FAS is recommended for evaluating pain levels. Rehabilitation should be maintained for grades A and B, while they should be halted for grade C	4.87±0.35	0.07
C. Out-of-hospital home-based rehabilitation	4.87±0.35	0.07
C1. Discharge Criteria	4.60±0.51	0.11
C1.1. The patient is medically stable, as characterised by stable vital signs, a pain score of 3 or less, good wound healing, the ability to dress independently, get in and out of bed, sit and stand up from a chair/toilet, use a walker/crutches independently, and walk>70 meters with crutches. At the same time, they have the mental ability to participate in continuous rehabilitation (they can use the Post Total Hip Replacement Discharge Scoring Scale, which includes gait and activity, daily life, total hip preventive measures, family exercise programs, patient characteristics, social support, psychology, cognition, and complications. The full score is 32 points, and the patients with discharge readiness≥25 points are considered "discharge ready", so patients are otherwise "not discharge ready")	4.67±0.49	0.10
C2. Home-based rehabilitation methods	4.87±0.35	0.07
C2.1. Three days before discharge, the patients and their families were given simulation, guidance and education on the content, frequency, duration and intensity of home rehabilitation, and the patients and their families cooperated and practised together. At the same time, the required rehabilitation were provided to the patients and their families in the form of words, pictures and videos	4.80±0.41	0.09
C2.2. Aerobic exercise is recommended, such as walking (at least 30 minutes of walking per day is recommended, and they are told how to develop their gait assistance from a walker to unassisted), stair climbing, swimming, low-impact tennis, and cycling	4.80±0.41	0.09
C2.3. Resistance exercise is recommended with a 1kg sandbag strapped to the affected lower leg for supine leg-raising exercises, side-lying leg-raising exercises, prone leg-raising exercises, and hip-raising exercises (activating the gluteus by stretching the bent buttock against resistance)	4.60±0.51	0.11
C2.4. Stretching exercise is recommended, including hip abduction/flexion, hip/knee flexion/extension, knee end flexion and extension, and ankle dorsiflexion/plantarflexion	4.80±0.41	0.09
C2.5. Weight-bearing exercise is recommended, including stepping in the same place, lateral stepping, and forward and backward stepping, with a walking aid discarded when there is no hip pain and no significant claudication	4.67±0.49	0.10
C2.6. Progressive balance and lower-extremity strengthening exercises are recommended, including standing knee flexion, lunge, sitting knee extension, and leg extension	4.73±0.46	0.10
C2.7. ADL exercise is recommended, including instructing the patient to perform fully autonomous walking exercises, walking up and down stairs, transferring, wearing and removing pants, and single-leg squatting pick-up exercises on the contralateral limb	4.80±0.41	0.09
C2.8. From the eighth week after surgery, patients were encouraged to gradually carry out bicycle riding (need to adjust the seat, hip flexion<90°), swimming and other activities at eight weeks post-operative.	4.33±0.82	0.19
C3. Duration and frequency of home-based rehabilitation	4.80±0.41	0.09
C3.1. Aerobic exercise: it is recommended to exercise 3–5 times/week, 30–60min/time is the best frequency, lasting for eight weeks	4.73±0.46	0.10
C3.2. Resistance exercise: gradually increase the number of resistance and exercise groups, starting with 15 times/group, gradually increase from 1 group to 3 groups, gradually increase from 10 minutes to 30 minutes, the interval of each group is 1–2 minutes, at least two times/week, lasting for eight weeks	4.80±0.41	0.09
C3.3. Stretching exercise: gradually increase the number of exercise groups. Each movement is a group of 15 reps, gradually increasing from 1 group to 3 groups, at least two times/week, lasting for eight weeks	4.80±0.41	0.09

(*Continued*)

Table 2 (Continued).

Items	Importance Assignment ($\bar{x} \pm s$)	CV
C3.4. Weight-bearing exercise: initially, it is supported by a table and chair or walking aid by increasing the number of repetitions and increasing the number of exercise movements, starting with 15 times for each movement, and then gradually increasing to 30 times, at least two times/week, lasting for eight weeks	4.80±0.41	0.09
C3.5. Progressive balance and lower-extremity strengthening exercises: four movements each five times/group, gradually increasing to 10 times/group within three weeks. Bilateral isometric and eccentric hip contraction exercises were performed twice daily for eight weeks after discharge	4.67±0.49	0.10
C3.6. ADL exercise: 2 times/d for eight weeks is recommended	4.73±0.46	0.10
C4. Intensity of home-based rehabilitation	4.87±0.35	0.07
C4.1. Aerobic and resistance exercises: based on RPE, it is recommended to start with moderate-intensity (12–13 points) exercise and then increase the load by 2.5% −5% every 2–4 weeks	4.67±0.49	0.10
C4.2. Weight-bearing exercise: gradually increase from post-discharge weight-bearing to full weight-bearing	4.67±0.49	0.10
C4.3. Progressive balance and lower-extremity strengthening exercises: standing knee flexion, lunge, sitting knee extension, and leg extension, four movements at an intensity of 70% 1RM for each set, increasing to 80% 1RM for each set after three weeks	4.60±0.51	0.11
C4.4. The rest of the post-operative exercises should be promptly discontinued upon the onset of fatigue and/or pain. FAS is recommended for evaluating pain levels. Rehabilitation should be maintained for grades A and B, while they should be halted for grade C	4.87±0.35	0.07
D. Follow-up	4.47±0.52	0.12
D1. Follow-up methods	4.33±0.72	0.17
D1.1. Online follow-up: telephone follow-up, WeChat voice or video follow-up (choose the appropriate follow-up method according to the education level and understanding ability of patients and their main caregivers), remote follow-up	4.73±0.46	0.10
D1.2. Offline follow-up: follow-up work was completed through outpatient follow-up or home visit	4.47±0.83	0.19
D2. Duration and frequency of follow-up	4.40±0.63	0.14
D2.1. Online follow-up: in the first month after discharge, telephone follow-up, WeChat voice or video follow-up was performed twice a week, about 30 minutes each time, and once a week in the second to third month after discharge. In the remote follow-up, patients were required to upload rehabilitation videos every 1–2 weeks to guide their movements and correct their deviation	4.67±0.49	0.10
D2.2. Offline follow-up: it is recommended to follow up one week, one month, three months, and six months after discharge, with a single outpatient follow-up of about 30 minutes and a home visit of about 1 hour	4.67±0.49	0.10
D3. Follow-up contents	4.53±0.52	0.11
D3.1. Patients were asked about their pain, including time, location, nature and accompanying symptoms. Patients were asked about their medication and rehabilitation compliance, including medication use and rehabilitation compliance, including important information such as medication dosage, course of treatment, and completion of rehabilitation	4.80±0.41	0.09
D3.2. Inquire about the range of motion of the affected limb, numbness and swelling of the affected limb (Harris hip score and comparative measurement of bilateral leg sensation and leg circumference were used in the outpatient follow-up)	4.80±0.41	0.09
D3.3. Patients were asked about post-operative health-related quality of life and activities of daily living (using the Barthel index and SF-36 health questionnaire), and individualised health education was carried out, such as emphasising maintaining the affected hip joint abduction position, avoiding low stools and soft sofas sitting or resting, avoiding using the squat toilet when going to the toilet. Do not cross your legs or feet	4.80±0.41	0.09
D3.4. Ask patients about their daily rehabilitation and whether complications and adverse events have occurred, so that the exercise can be modified as appropriate (either to reduce the number of repetitions or to skip training for a few days because of pain or fatigue) and advise patients that they can record in a diary or video	4.80±0.41	0.09

Abbreviations: FNFs, Femoral Neck Fractures; HA, Hemiarthroplasty; THA, Total Hip Arthroplasty; AAOS, American Academy of Orthopedic Surgeons; RPE, Rating of Perceived Exertion Scale; ERAS, enhanced recovery after surgery; ADL, Activities of Daily Living; PTHRDSS, Post Total Hip Replacement Discharge Scoring Scale; VAS, Visual Analogue Scale.

operatively"; frequency: "one set every 2 hours"; intensity: "RPE 12–13, progressing to 14–16"), achieving low coefficients of variation that indicate strong expert agreement on their feasibility. This specificity directly addresses the interview-identified challenge where generalized descriptions left clinicians uncertain about implementation, thereby enabling standardized replication across institutions with varying resources. Third, our program integrates international evidence with Chinese-specific adaptations validated by multidisciplinary experts from diverse regions. These include respiratory exercises, family-centered care models reflecting that Chinese geriatric FNFs patients rely primarily on family caregivers, and localized assessment tools (PTHRDSS Chinese version). This context-specific optimization addresses the previously neglected gap in adapting rehabilitation protocols to Chinese healthcare realities.[21–23]

These outcomes were achieved through a rigorous methodological approach. Research has demonstrated that the number of experts, the breadth of the professional field, and the accumulation of knowledge and experience are crucial to constructing effective intervention programs.[63] This study is grounded in the Model for Evidence-Based Practice Change and utilises the 'Guidelines for the Treatment and Management of Hip Fractures in Older People' published by the Department of Medical Administration of the National Health Commission of the People's Republic of China[64] in 2022, alongside the new 'Clinical Practice Guideline Summary: Management of Hip Fractures in Older Adults' from AAOS[47] as a benchmark. This evidence-based approach enabled the systematic development of an intervention program that addresses identified gaps while adhering to established clinical standards.[65]

The proposed interventions align closely with China's Enhanced Recovery After Surgery (ERAS) protocols and, importantly, address a critical gap in clinical practice by targeting the absence of standardized, comprehensive rehabilitation guidelines specifically tailored for this vulnerable population within the Chinese healthcare context. The program provides a unified, operationalized framework that integrates pre-operative preparation, post-operative in-hospital care, and home-based rehabilitation with clearly defined parameters for methods, duration, frequency, and intensity. A key finding of this study is the high level of expert consensus regarding the necessity of pre-operative rehabilitation, despite variability in opinions about specific methodologies. This consensus underscores a paradigm shift in geriatric fracture care, recognizing that optimizing patients' functional status before surgery can significantly influence post-operative outcomes. To operationalize this concept, our program emphasizes establishing multidisciplinary teams comprising orthopedic surgeons, anesthetists, rehabilitation nurses and therapists, nutritionists, and clinical pharmacologists.[66–68] This team-based approach ensures comprehensive assessment and personalized intervention planning that addresses not only physical function but also nutritional status, medication management, psychological wellbeing, and lifestyle modifications. Our preliminary interviews revealed that most patients exhibited limited understanding of their conditions and rehabilitation,[65] highlighting the necessity of patient education. The program incorporates evidence-based recommendations for smoking and alcohol cessation,[69,70] medication optimization to prevent anemia exacerbation,[71] and psychological intervention,[72] thereby addressing modifiable pre-operative risk factors comprehensively. Our study provides specific guidance on team composition and role distribution within the Chinese clinical setting, thereby enhancing feasibility and implementation.

The highest importance ratings from experts were assigned to in-hospital post-operative rehabilitation, reflecting consensus on both the critical timing and optimal implementation strategies during this period.[73] Building upon existing evidence supporting immediate mobilization within 24 hours post-surgery (barring medical contraindications),[47,50–57,74] our program standardizes rehabilitation protocols that were previously inconsistent across institutions. This standardization addresses methodological limitations observed in earlier studies. For instance, trials reporting no benefit from multidisciplinary pre-rehabilitation often lacked uniform exercise standards.[75] Our program align with the standards outlined in the Physical Activity Guidelines for Chinese (2021),[76] establishes consistent parameters for methods, duration, frequency, and intensity, while preserving flexibility for individualized adjustments based on patient-specific factors such as fatigue, pain tolerance, and functional capacity. Evidence suggests that continuous and regular rehabilitation enables patients to reach discharge criteria faster and improve early motor function.[77] Therefore, we synthesized findings from multiple studies to integrate resistance, balance, proprioceptive, and weight-bearing exercises with graduated progression principles. The incorporation of the Rating of Perceived Exertion (RPE) scale for intensity monitoring and adherence to 8–12 week exercise durations provides clinicians with practical, evidence-informed

benchmarks that were absent in earlier exercise programs. This standardization is expected to enhance treatment consistency and facilitate quality improvement initiatives across Chinese healthcare facilities.

Geriatric patients post-discharge face unique challenges including limited self-care capacity, higher complication risks, and prolonged functional recovery time.[78] Recognizing these challenges, our program emphasizes continuity of care through structured home-based rehabilitation and systematic follow-up protocols. To address the identified gap in discharge readiness, we recommend the Post Total Hip Replacement Discharge Scoring Scale (PTHRDSS), which has been validated in Chinese populations,[79] to objectively assess patients' preparedness across dimensions of preventive measures, daily living function, and home exercise capability. Additionally, we designed a 3-day pre-discharge simulation training program for family caregivers to ensure adequate preparation for home-based rehabilitation management. Our follow-up schedule includes initial assessment at 3–7 days post-discharge with subsequent evaluations at standardized intervals.[80] This schedule is designed to mitigate the elevated 30-day readmission risk documented in geriatric populations, aligning with recommendations for continuous post-discharge support.[81] The program employs validated outcome measures including the Harris hip score, SF-36 health questionnaire, and Barthel index at specified intervals[82–85] to systematically evaluate rehabilitation effectiveness. The integration of internet-based telemedicine platforms[86] represents an innovative adaptation to China's rapidly developing digital health infrastructure, enabling sustained patient monitoring, real-time guidance, and enhanced adherence across diverse geographic and socioeconomic contexts. This comprehensive post-discharge approach distinguishes our program from existing protocols that predominantly focus on in-hospital interventions.

Several limitations warrant consideration when interpreting our findings. Despite comprising professionals from multiple disciplines and geographic regions within China, our expert panel utilized the Delphi methodology, which inherently reflects expert opinion rather than empirical clinical outcomes. Although our program is grounded in systematic literature review and evidence synthesis, large-scale randomized controlled trials in the target population have not yet validated these recommendations. The generalizability of certain recommendations, particularly those related to healthcare system structure and resource availability, may be limited in settings with substantially different clinical contexts. Additionally, while our program provides general guidelines, further adaptation may be necessary for specific patient subgroups, such as those with advanced age (over 85 years), severe cognitive impairment, or multiple complex comorbidities.

Future research should prioritize rigorous evaluation of this exercise program through multi-center randomized controlled trials to establish its efficacy in improving functional outcomes, reducing complications, and enhancing quality of life in geriatric FNFs patients undergoing THA. Comparative effectiveness studies examining different components of the program and cost-effectiveness analyses would further inform optimal implementation strategies. Additionally, development and validation of digital health tools specifically designed to support program delivery, including mobile applications for home exercise guidance and remote monitoring systems, represent important next steps. Subgroup analyses exploring optimal rehabilitation protocols for patients stratified by age, frailty status, and comorbidity burden would enable more precise personalization of care.

In conclusion, this evidence-based exercise program provides a comprehensive, standardized, and culturally adapted framework for optimizing recovery in geriatric FNFs patients undergoing THA in China. By addressing critical gaps in pre-operative preparation, post-operative care standardization, and post-discharge continuity, this program has the potential to improve clinical outcomes and quality of life for this vulnerable population while supporting broader implementation of ERAS principles in geriatric orthopedic care.

Conclusions

Based on the Model for Evidence-Based Practice Change, guidelines, and expert consensus, this study developed a exercise program tailored to the characteristics of geriatric FNFs patients in China. Through a rigorous two-round Delphi consultation process involving 15 multidisciplinary experts, the program achieved high levels of consensus, incorporating four first-level items, seventeen second-level items, and 63 third-level items. The program demonstrates strong content validity and expert consensus regarding its clinical applicability and feasibility within the Chinese healthcare context. This expert consensus-based framework provides detailed, operationalized guidance for clinicians

implementing rehabilitation protocols for geriatric FNFs patients. While the program shows promise as a reference for exercise program development in other fracture populations, its clinical effectiveness requires validation through prospective implementation studies and randomized controlled trials in diverse clinical settings. The findings establish a foundation for future research to evaluate the program's impact on patient outcomes, and broader applicability across different healthcare contexts and patient populations.

Data Sharing Statement

The partial data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Consent for Publication

All authors have approved the publication of our manuscript.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the principles of the Declaration of Helsinki. The study was also approved by the Ethical Review Board (ERB) of the Zhejiang Chinese Medical University (code: 20231117-9). All participants were fully informed about how their data and information would be used in this study, and their right to withdraw their participation at any time. All participants were provided with an information sheet and the purposes of the study were described in-depth. Written Informed consent was obtained from all the participants of the study.

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Disclosure

The authors report no conflicts of interest in this work.

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