Journal of Orthopaedic Surgery and Research

STUDY PROTOCOL Open Access

Effect of early rehabilitation on hospital stay and postoperative complications in elderly hip fracture patients: a prospective cohort study

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Abstract

Background Hip fractures in the elderly are a major global public health concern, with incidence projected to rise as populations age. Rehabilitation is critical to recovery after hip fracture surgery, but the ideal timing for initiation remains uncertain. While early rehabilitation, within 48 h post-surgery, is associated with better outcomes, its specific impact on hospital stay duration and postoperative complications is not yet conclusively established.

Aim This study aims to evaluate the effects of initiating rehabilitation within 48 h after hip fracture surgery on hospital length of stay and postoperative complications, compared to rehabilitation started one-week post-surgery in elderly patients. It is hypothesized that early rehabilitation will significantly reduce hospital stays and decrease the rate of postoperative complications.

Methods In this prospective cohort study, patients aged 65 and older are divided into early rehabilitation (within 48 h) and delayed rehabilitation (after one week) groups. Data will be collected using electronic medical records (EMR), standardized clinical tools (Barthel Index, Timed Up and Go), and patient-reported outcome measures (SF-36, EQ-5D). Statistical analyses will include t-tests and chi-square tests for outcome comparison, with multiple regression adjusting for potential confounders such as age, gender, and comorbidities.

Significance
This study addresses a gap in current research by comparing early versus delayed rehabilitation for elderly hip fracture patients. The findings will contribute to the development of evidence-based rehabilitation protocols aimed at optimizing recovery, reducing complications, and improving the efficient use of medical resources.

Keywords Early rehabilitation, Hospital stay, Postoperative complications, Elderly patients, Hip fracture, A prospective cohort study

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Introduction

Hip fractures are an escalating public health concern in aging societies worldwide, with the global incidence projected to reach approximately 4.5 million cases annually by 2050 [1, 2]. These fractures disproportionately affect elderly individuals, with over 90% of cases occurring in patients aged 65 and older, many of whom have comorbidities that complicate recovery [3]. Surgical interventions, such as hip arthroplasty, internal fixation, or cephalomedullary nailing for unstable intertrochanteric fractures, are often necessary to stabilize fractures [4, 5]. Early surgical intervention, particularly within 48 h of admission, has been shown to significantly reduce mortality in elderly hip fracture patients [6]. However, even with timely and successful surgery, these patients remain at high risk for long-term complications, including permanent disability, long-term dependence, and postoperative complications, all of which contribute to rising healthcare costs [2]. The expected rise in hip fractures underscores the critical need for optimizing care strategies to improve recovery outcomes and reduce healthcare resource utilization [7].

While surgery is essential, postoperative rehabilitation is equally critical for successful recovery [8]. There is growing recognition of the benefits of early rehabilitation, particularly within 48 h post-surgery, in enhancing recovery, improving physical function, and reducing complications [2]. Studies have shown that early rehabilitation significantly improves postoperative outcomes by reducing complications such as thromboembolism, pneumonia, and pressure ulcers, and by promoting faster functional recovery [5]. Moreover, maintaining muscle mass is vital for recovery, especially in sarcopenic patients who are at higher risk of poor functional outcomes, further emphasizing the importance of early rehabilitation interventions [9]. Despite these findings, there remains a lack of consensus regarding the optimal timing of rehabilitation to minimize hospital stays and reduce postoperative complications.

The primary aim of this study is to evaluate whether initiating rehabilitation within 48 h post-surgery can reduce the length of hospital stay and the incidence of postoperative complications in elderly hip fracture patients, compared to rehabilitation initiated one-week post-surgery. Addressing this research question will provide critical evidence for improving postoperative care practices, potentially improving outcomes for a vulnerable population and reducing overall healthcare costs.

Literature review

A comprehensive search of PubMed, CINAHL, Medline via Ovid, and Cochrane databases was conducted for studies published between 2000 and 2024. Search terms included "elderly patients," "hip fracture," "rehabilitation," "length of stay," "early mobilization," and "postoperative complications." The focus was on studies examining the timing and effectiveness of early rehabilitation in elderly hip fracture patients, particularly in relation to hospital length of stay and reduction of postoperative complications.

Hip fractures are a major cause of morbidity and mortality in the elderly, placing a significant burden on healthcare systems worldwide [10, 11]. Elderly patients with hip fracture often experience a longer recovery period and an increased risk of postoperative complications, including thromboembolism, pneumonia, wound dehiscence, and pressure ulcers, due to the presence of age-related physiological decline and comorbidities [3]. Commonly employed surgical treatments for hip fractures include hip arthroplasty and internal fixation, both of which require substantial postoperative rehabilitation to restore function and promote independence [4]. For more complex fracture types, such as reverse oblique intertrochanteric fractures, cephalomedullary nailing has emerged as the preferred surgical intervention, offering superior biomechanical stability, reduced soft tissue damage, and the ability to support early mobilization [5]. In addition, multidisciplinary approaches, such as the involvement of orthogeriatricians, have been shown to optimize postoperative outcomes, particularly in reducing the need for transfusions and improving hemoglobin management [12].

Postoperative rehabilitation has emerged as a critical determinant of recovery outcomes in elderly patients. Research has consistently shown that early initiation of rehabilitation following surgery is associated with better long-term functional outcomes, faster recovery of independence, and reduced healthcare resource use [13, 14]. Starting rehabilitation within 48 h post-surgery has been linked to significant improvements in physical function and a reduced incidence of complications [2]. This is especially important given the known risks associated with prolonged hospital stays, including hospital-acquired infections, psychological distress, and increased dependency [1]. For example, early rehabilitation has demonstrated significant benefits in reducing muscle mass loss, a critical factor influencing recovery, particularly in sarcopenic patients [9]. Furthermore, it has been associated with fewer complications, such as thromboembolism and pneumonia, and a lower risk of hospital-acquired infections [5].

Despite these documented benefits, a significant gap persists regarding the optimal timing of rehabilitation initiation. Some studies have shown that early rehabilitation, especially within the first 48 h, can mitigate complications and accelerate recovery, while others suggest that delayed rehabilitation may still offer comparable outcomes depending on patient conditions and

healthcare settings [6, 15]. Moreover, the impact of early rehabilitation on hospital length of stay remains a key area of debate, with existing research providing inconsistent results on whether early rehabilitation consistently reduces hospital stays or simply shifts resource demands [1]. Additionally, challenges such as variation in rehabilitation protocols and patient comorbidities contribute to inconsistent outcomes [12, 16].

This literature review highlights the critical need for more robust, comparative studies that directly assess the effects of early versus delayed rehabilitation, particularly in elderly populations at high risk for postoperative complications. Furthermore, existing studies have largely been limited by sample size, lack of generalizability, or inconsistent rehabilitation protocols. The current study addresses these gaps by exploring the effects of early rehabilitation (within 48 h post-surgery) versus delayed rehabilitation (one-week post-surgery) on hospital length of stay and postoperative complications in elderly hip fracture patients. This research will contribute to the development of evidence-based rehabilitation protocols, informing best practices in postoperative care for this vulnerable population.

Study aims

The present study was a prospective cohort study designed to evaluate the effect of starting rehabilitation training within 48 h after hip fracture surgery on the length of hospital stay in patients aged 65 years and older. Specifically, the primary objective of the study was to determine whether early rehabilitation training (within 48 h after surgery) could significantly reduce the length of hospital stay, as compared with rehabilitation training initiated 1 week after surgery. This study will further clarify the specific impact of early rehabilitation on the hospital course of patients at different time points through objective clinical data, to provide data support for optimizing the timing of rehabilitation.

The secondary objective was to examine the effect of early rehabilitation (within 48 h after surgery) on the incidence of postoperative complications, focusing on common postoperative complications such as thromboembolism, pneumonia, wound breakdown, pressure ulcers, and delirium. By analysing the relationship between the start time of rehabilitation and these complications, research will more comprehensively evaluate the impact of early rehabilitation on the overall prognosis and long-term recovery of patients, to make more targeted clinical recommendations for rehabilitation intervention in elderly patients with hip fracture.

Hypothesis

- Starting rehabilitation within 48 h after surgery will significantly shorten the length of hospital stay for hip fracture patients aged 65 years and older, compared with starting rehabilitation within 7 days after surgery.
- Compared with delayed rehabilitation, early rehabilitation treatment will significantly reduce the incidence of postoperative complications, including thromboembolism, pneumonia, wound rupture, pressure ulcers, and delirium.

Methods

This study used a prospective cohort design to evaluate the effect of starting rehabilitation within 48 h after hip fracture surgery on length of hospital stay and postoperative complications in patients aged 65 years and older. Because it allows longitudinal, real-time data collection from a clearly defined baseline, that is, after surgery. This allows for observation of effects of rehabilitation over time and identification of temporal relationships between timing of recovery and outcomes [17].

The cohort divided into two groups based on exposure: patients who received early rehabilitation (within 48 h after surgery) and those who received delayed rehabilitation (within 1 week after surgery). The design minimized recall bias and provided a clearer understanding of the causal impact of early rehabilitation. Statistical adjustments were made to control for confounding factors such as age, comorbidities, and surgical characteristics to ensure robust and reliable results [18]. The study timeline, as shown in Fig. 1, provides a detailed overview of key phases such as study setup, participant recruitment, data collection, data cleaning, analysis, and report writing.

Study setting

The study will be conducted at the Royal Melbourne Hospital, St Vincent's Hospital, Melbourne, and Richmond Hospital, Epworth, all in Melbourne, Australia. These hospitals are known for their well-established orthopedic and rehabilitation facilities, and each provides comprehensive postoperative rehabilitation services for patients with hip fractures. These hospitals provided an ideal setting for observing early versus delayed rehabilitation interventions, ensuring the feasibility of the study, given the large number of elderly patients and the good hospital infrastructure.

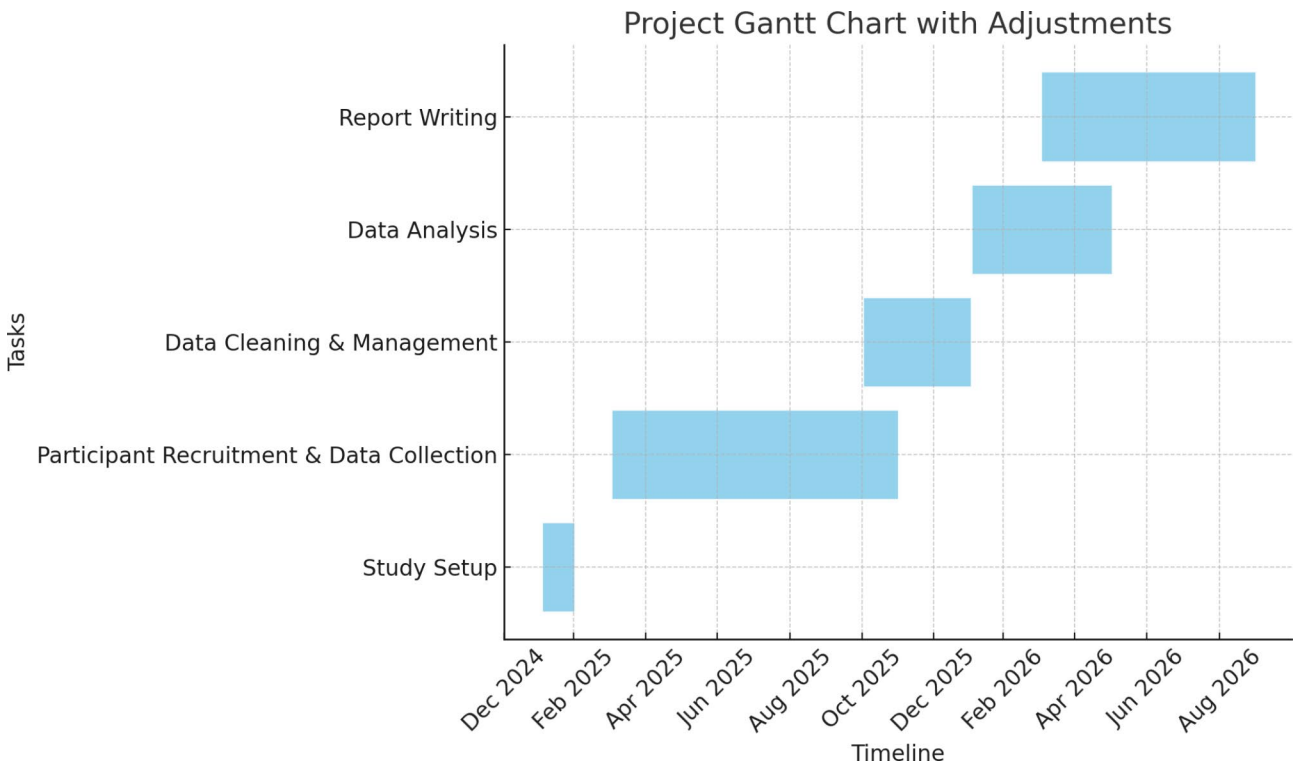

Fig. 1 Project Gantt Chart. Figure 1 illustrates the planned timeline of the study, visually summarizing the key phases such as setup, recruitment, data collection, and analysis. This chart serves to align all critical activities and their durations within the project scope

Study participants

Inclusion criteria

- Patients aged ≥ 65 years who have undergone surgical treatment for a hip fracture, including hip arthroplasty or internal fixation.
- Patients who are healthy and suitable to participate in postoperative rehabilitation.
- Patients who have provided written informed consent agreeing to participate in early rehabilitation (within 48 h after surgery) or delayed rehabilitation (7 days after surgery).

Exclusion criteria

- Patients with hip fractures caused by high-energy trauma (e.g., car accidents, falls) due to complex injuries and different rehabilitation needs that lead to confusing study results. These patients typically have more complex injuries and rehabilitation needs, which may confound the study results focused on typical low-energy trauma fractures common in the elderly [19].
- Patients with severe pre-existing comorbidities, such as end-stage cardiopulmonary disease, or cognitive impairments that preclude participation in rehabilitation. Such conditions would make it difficult for the patient to adhere to or benefit from rehabilitation interventions, thereby potentially skewing study outcomes.
- Patients who were unable to provide informed consent or who did not have a legal representative to provide consent on their behalf.
- Patients who had critical postoperative complications (e.g., thromboembolism, pneumonia, wound ulceration, pressure ulcers, or delirium) before study entry, as the study was focused on preventing rather than managing these complications.

Sample size

The method for determining the sample size is based on Soper (2024) [20]. A priori sample size calculator for multiple regression [Software]. Available from http://www.danielsoper.com/statcalc. The expected effect size (f^2) was set to 0.15, the desired level of statistical power to 0.8 and the significance level to 0.05. The model contains five predictor variables: age, sex, type of surgery (e.g., hip arthroplasty or internal fixation), comorbidities, and rehabilitation timing (early vs. delayed rehabilitation). These variables were selected based on their correlation with postoperative outcomes in elderly patients with hip fracture. Based on these parameters, the calculator determined that the minimum sample size required was 91 participants. Adequate statistical power was ensured by

ensuring that the sample size was valid to detect statistically significant differences in the primary and secondary outcomes to account for potential loss to follow-up and withdrawal [21]. The final target sample size was 100 participants, with 50 participants per group.

Sampling method and recruitment

Sampling method

Stratified random sampling will be used in this study to account for variables such as age, gender, type of surgery, and comorbidities and to minimize confounding. Patients will be naturally grouped according to the usual hospital rehabilitation pathway: an early rehabilitation group (starting rehabilitation within 48 h after surgery) or a delayed rehabilitation group (starting rehabilitation within 1 week after surgery). This grouping method retained the natural observational design of the study and could truly reflect the impact of the timing of rehabilitation on postoperative recovery in clinical practice. The investigators did not interfere with the trial-group assignments to ensure the authenticity and reliability of the study results [22]. In addition, in the data analysis phase, multivariate regression models will be used to control for confounding factors, ensuring that the effect of group bias on the study results is minimized [23].

Recruitment process

1. Patient identification Eligible participants will be identified from the orthopaedic and rehabilitation departments of the three participating hospitals. Patients meeting the inclusion criteria will be screened based on hospital records.

2. Stratification and sampling Patients will be stratified according to key variables, including age (65–74 years, 75–84 years, ≥ 85 years), sex, type of surgery (e.g., hip replacement, internal fixation), and comorbidities. Patients were naturally divided into two groups according to the hospital rehabilitation pathway: the early rehabilitation group included patients who started rehabilitation within 48 h after surgery, and the delayed rehabilitation group included patients who started rehabilitation 1 week after surgery.

3. Notification and informed consent Eligible patients will be contacted within 24 to 48 h after surgery and informed of possible study participation. The research team will explain the purpose, methods, risks and benefits of the study and obtain written informed consent from all participants or their legal representatives. All consents will be recorded using standardized forms and securely stored in the study database.

4. Grouping After consent is obtained, participants will be naturally assigned to early or delayed rehabilitation based on their clinical status. The grouping method was based on the routine clinical pathway of the hospital, and the researchers did not interfere with the grouping, thus preserving the natural observation design, so that the effect of rehabilitation timing on postoperative recovery could be truly evaluated.

5. Recruitment continues Recruitment will continue until 50 participants have been recruited in each group, for a total sample size of 100. This sample size will ensure that the study has sufficient statistical power to detect significant differences between early and delayed rehabilitation interventions.

Data collection methods

This study will use a multi-source approach to collect primary and secondary data, ensuring comprehensive and accurate measurement of key outcomes. The following methods and tools will be used:

Data sources

- Electronic medical record (EMR): The EMR will be used to collect objective clinical data, such as length of hospital stay and postoperative complications. This system provides a reliable source for standardizing clinical outcomes [24].
- Standardized clinical assessment tools: tools such as the Barthel Index and the Timed Up and Go (TUG) test will assess functional recovery and activities of daily living. These validated instruments ensure consistent data collection across all study sites, thereby improving data reliability and comparability [25].
- Patient-reported outcome Measures (PROM): The SF-36 health survey and the EQ-5D will capture the physical and mental health dimensions, providing a holistic view of a patient's health-related quality of life [26].

Primary outcome - hospital length of stay

The length of stay will be determined based on the date of surgery, admission, and discharge from the EMR.

Secondary outcome - postoperative complications

Postoperative complications: Standardized clinical assessment and EMR data will be used to document complications such as thromboembolism, pneumonia, wound rupture, pressure sores, and delirium.

Demographic data

Key demographic variables, including age, sex, race, and marital status, will be extracted from the EMR. This information will be used to adjust for potential confounding variables in the analysis.

Rehabilitation progress

Physiotherapists will document mobility recovery and functional milestones using standardized templates. These templates ensure consistency across sites and facilitate clear comparisons between the two rehabilitation groups.

Data collection team

A team of trained registered nurses (RN) and physical therapists experienced in hip fracture care and clinical research will collect data. They will receive specific training on data collection protocols and standardized tools to ensure reliability and consistency of data across all study centers. Importantly, the team will maintain objectivity throughout the study, independent of patient care and data analysis.

Location and timeline

Data will be collected at three public hospitals in Melbourne Baseline data for the early and delayed rehabilitation groups will be collected within 48 h after surgery. All data collection will take place during the patient's hospital stay, ensuring complete monitoring of recovery and postoperative complications. Daily data will be collected throughout the hospital stay, in line with standard clinical practice for monitoring recovery and supported by recent literature [27]. The timeline for the study, as shown in Fig. 1, provides a detailed representation of the data collection phases and their alignment with other critical study activities.

Rehabilitation intervention

Content The program will include both active and passive exercises, such as bed-based range of motion (ROM) exercises, progressive weight-bearing, and breathing exercises [28]. As the patient's condition improves, walking and weight-bearing exercises with assistive devices are introduced [2].

Frequency Training was performed for 30 min to 1 h per day, with intensity gradually increasing after the first week, aiming to reach two sessions per day by the second week [29].

Goals Rehabilitation programs are designed to enhance hip function, prevent complications (e.g., DVT, pneumonia), and support early recovery of independent mobility [3].

Rehabilitation execution

Team Supervised by a physical therapist and registered nurse. Both teams will receive specific training to standardize treatment protocols.

Location Depending on the patient, the intervention will be delivered at the bedside or in a dedicated rehabilitation room equipped with specialized equipment.

Data management

To protect privacy, patient demographics, clinical variables and outcomes will be anonymized by unique identifiers and data will be stored in a passor-protected database accessible only to authorized personnel and retained for at least 15 years in accordance with Monash University policy [30]. To ensure data accuracy, data cleaning will be performed periodically to address outliers and missing data. Data missing not at random will be handled using methods such as multiple imputation [31].

Data analysis

Data analysis will focus on two primary outcomes: length of hospital stays and postoperative complications. Descriptive statistics will be used to summarize demographic and baseline characteristics of the patients [32]. The t-test will be used for measurement data statistics between the two groups, the U-test will be used for count data comparison between the two groups, and the chi-square test will be used to analyze the incidence of postoperative complications [33]. If there are differences in the demographic data between the two groups, to ensure the accuracy of the analysis results, multivariate regression analysis will be used to adjust for confounding factors such as age, gender and comorbidities [23]. All data analysis will be performed using SPSS software, and statistical significance will be set at $P < 0.05$.

Rigour

1. **Internal validity** Multiple regression analyses will be used to control for confounding variables such as age, sex, comorbidities, and type of surgery, ensuring that any differences observed between groups are attributable only to time to recovery [23, 34].

2. **Reliability** Data consistency was ensured through standardized forms and validated instruments such as the SF-36 health survey. All data collectors will

receive uniform training to ensure standardized practice across study sites [26].

3. **External validity** Recruitment of participants from multiple hospitals increases the generalizability of the findings to the wider population of older patients with hip fractures [34].

4. **Statistical power** Sample size calculations ensure sufficient power to detect significant differences, minimizing the risk of Type II errors [21].

5. **Minimizing bias** Selection and measurement bias were minimized by stratified random sampling and the use of standardized data collection methods to ensure accurate and representative results [18, 23].

Ethical considerations

1. **Informed consent** All participants must provide informed consent, ensuring they understand the purpose of the study, procedures, risks, and benefits. The consent process should be voluntary, and participants must be informed of their right to withdraw at any time without any consequences. Consent forms should be clear and clear and avoid the use of technical terms that may confuse participants [35].

2. **Privacy and confidentiality** Participant identities will be anonymized through unique identifiers, ensuring that personal data are not identified. Only authorized personnel will have access to data, which will be stored securely in password-protected systems. Studies should comply with data protection regulations and personal identifiers should not be linked to published results [35, 36].

3. **Minimizing harm** Since this study involves elderly patients who may be vulnerable, careful consideration must be given to minimizing any risk of harm. Participants must not be exposed to interventions that could exacerbate their condition. Physical rehabilitation will be performed within a clinically safe framework, under close supervision, to avoid injury or excessive strain [35].

4. **Justice and equity** Stratified random sampling will ensure equal representation across different age groups, surgery types, and comorbidity levels, ensuring fairness in participant selection and avoiding bias. Recruitment efforts will be inclusive, providing all eligible participants an equal opportunity to participate [35].

5. **Risk management** Any potential adverse events, such as complications during rehabilitation, will be addressed with predefined clinical protocols. Participants experiencing significant deterioration in health during the study will receive appropriate medical care immediately, and their participation will be reassessed based on medical advice [35].

The above considerations will be submitted to the institutional ethics committee for approval to ensure that all ethical standards are fully addressed. This process ensures that the study aligns with both local institutional guidelines and broader ethical frameworks.

Significance

This study is of particular importance to Melbourne's public hospitals, especially for the Melbourne public hospitals where this study is being conducted. By demonstrating the benefits of early rehabilitation (within 48 h after surgery), this study could directly inform and optimize current postoperative care protocols. Implementing this evidence-based practice could significantly improve the quality of care in these institutions by reducing length of stay, improving patient outcomes, and using health care resources more efficiently.

Beyond its immediate local impact, the findings have broader implications for healthcare systems globally, especially in aging societies. Hip fractures are a major contributor to morbidity, mortality, and rising healthcare costs among elderly populations. The results of this study could serve as a basis for refining rehabilitation guidelines and establishing early rehabilitation as a standard practice. Such evidence could lead to a reduction in postoperative complications, faster recovery of functional independence, and overall improved quality of life for patients.

In addition, this study may influence health care policy by providing robust data supporting early rehabilitation as a key intervention. Policy makers can use these findings to promote strategies that prioritize early rehabilitation, improving patient outcomes while reducing healthcare expenditures associated with prolonged hospital stays and complications. In this way, this research not only advances clinical practice, but also contributes to the development of more sustainable medical policies at national and international levels, making a significant innovative contribution to the field of geriatric care and rehabilitation.

Acknowledgements
This work was supported by the Natural Science Foundation of Hunan Province of China under Grant 2024JJ6408.

Author contributions
(1), Wen Tang, Yanhui Zhou and Huayong Huang conceiving and designing the study; (2), Wen Tang, Yiqi Wang, Yulian He, Bo Liu and Runzhi Yuan

collecting the data; (3), Wen Tang, Yiqi Wang, Yulian He, Bo Liu and Runzhi Yuan analyzing and interpreting the data; (4), Wen Tang writing the manuscript; (5), Yanhui Zhou and Huayong Huang providing critical revisions that are important for the intellectual content; (6), All authors approving the final version of the manuscript.

Funding
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The above considerations will be submitted to the institutional ethics committee for approval to ensure that all ethical standards are fully addressed. This process ensures that the study aligns with both local institutional guidelines and broader ethical frameworks.

Consent for publication
All participants must provide informed consent, ensuring they understand the purpose of the study, procedures, risks, and benefits. The consent process should be voluntary, and participants must be informed of their right to withdraw at any time without any consequences. Consent forms should be clear and clear and avoid the use of technical terms that may confuse participants.

Competing interests
The authors declare no competing interests.

Received: 20 November 2024 / Accepted: 10 December 2024
Published online: 23 January 2025

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