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REVIEW

Best Evidence Summary on Early Exercise for Prevention of ICU-Acquired Weakness: An Evidence-Based Synthesis

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Purpose: This study systematically aimed to identify and synthesize the highest-quality available evidence regarding the preventive impact of early exercise interventions on intensive care unit acquired weakness (ICUAW) in critically ill adults.

Methods: Utilizing the evidence-based 6S model, we conducted a comprehensive literature review across multiple databases. The review concentrated on evidence related to early exercise in intensive care unit (ICU) patients, specifically evaluating early assessment strategies, risk management, appropriate intensity and prescription of exercise interventions, safety considerations, and the role of multidisciplinary collaboration. The literature search was performed from database inception to April 30, 2025. Two independent researchers evaluated literature quality and extracted data, systematically synthesizing evidence from studies that met predefined inclusion criteria.

Results: A total of 24 studies were included: 6 clinical guidelines, 8 randomized controlled trials, 7 systematic reviews, and 3 expert consensus statements. Taken together, current evidence converges on a key practice approach that integrates routine early assessment of muscle strength and functional status, risk-stratified and progressively advanced exercise, individualized titration of exercise intensity and frequency according to hemodynamic stability and level of consciousness, explicit safety thresholds and stopping criteria, and delivery by a coordinated multidisciplinary team of nurses, physicians, and rehabilitation professionals.

Conclusion: This review synthesizes high-quality evidence supporting the use of targeted early exercise interventions to prevent intensive care unit–acquired weakness (ICUAW), thereby providing an evidentiary foundation for clinicians to develop individualized intervention plans and to improve both short-term clinical outcomes and long-term recovery in critically ill ICU patients. Future research should, within a multidisciplinary team framework, conduct large-scale, multicenter cohort studies to determine the optimal initiation timing and dosage of early exercise, with the ultimate aim of further reducing the incidence of ICUAW and optimizing patient prognosis.

Trial Registration: This study was based on the evidence summary reporting specifications of the Fudan University Center for the Evidence-based Nursing, the register name is "Best evidence summary on early exercise for the prevention of ICU-acquired weakness in critically ill patients", the registration number is "ES20257998".

Keywords: critically ill patients, intensive care unit-acquired weakness, exercise, evidence summary, prevention

Introduction

Intensive care units primarily manage acutely and critically ill patients who require continuous monitoring and advanced organ support.[1] This population represents the primary high-risk group for intensive care unit–acquired weakness (ICUAW). Intensive care unit-acquired weakness (ICUAW) describes the acute development of diffuse muscle weakness observed in a substantial

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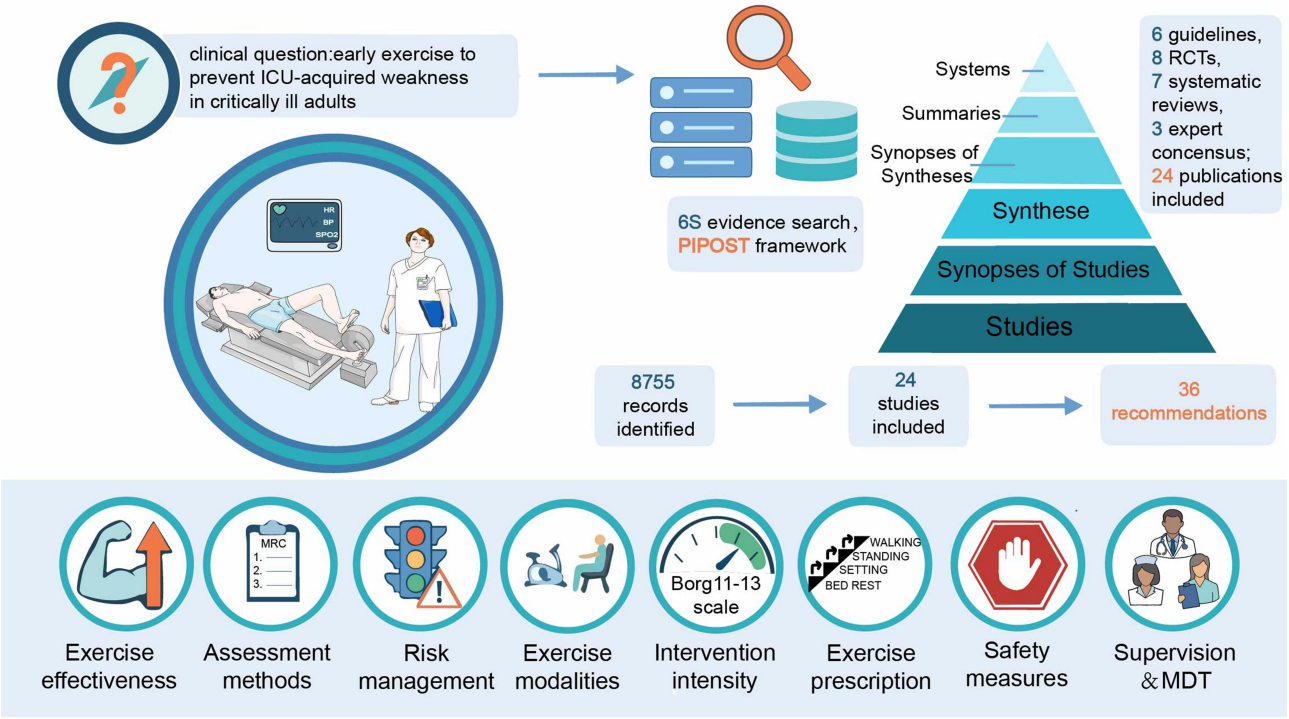
Graphical Abstract



proportion of patients admitted to intensive care units (ICUs) following severe trauma, burns, complex surgery, or acute infections.[2] This condition results from a multifactorial pathogenesis involving microvascular impairment, electrical conduction abnormalities, alterations in metabolism, and disrupted energy dynamics, ultimately resulting in marked muscle strength reduction and atrophy.[3] A global systematic review including data from multiple countries reported that up to 48% of ICU patients develop ICUAW, with the observed incidence varying according to patient population and the timing of assessment.[4,5] ICUAW is associated with prolonged ICU and hospital stays, increased dependence on mechanical ventilation, and elevated mortality rates both during the acute phase and after discharge.[6,7] Importantly, ICUAW may persist for years after hospital discharge, correlating with an increased risk of one-year mortality and causing substantial limitations in physical function and quality of life.[8,9] Additionally, the enduring sequelae of ICUAW can significantly diminish overall functional capacity, complicate return to work, and impose a considerable economic burden due to prolonged need for ongoing care.[10–12] As such, there is a compelling clinical imperative to develop evidence-based, practical early interventions for the prevention or attenuation of ICUAW.

Systematic implementation of early exercise for ICU patients has been strongly advocated as an effective intervention to optimize outcomes. Multiple studies have demonstrated that early exercise interventions can improve physical function, reduce the risk and severity of ICUAW and delirium, significantly mitigate neuromuscular dysfunction, and facilitate muscle recovery, thereby playing a critical preventive and therapeutic role in ICUAW.[13,14] However, substantial variation persists in the real-world implementation of early mobilization and rehabilitation across regions and health-care systems. In Brazil, mobilization activities are highly prevalent, with 87.4% of critically ill patients receiving mobilization.[15] In a cross-sectional survey of Swiss intensive care units, respondents reported that 82% of patients underwent early mobilization during their ICU stay.[16] By contrast, a multicenter cross-sectional survey of 444 ICUs in 11 provinces in China showed that, among the 253 units that had introduced early mobilization, only 21.34% routinely provided early mobilization to all eligible patients.[17] These discrepancies likely reflect a complex interplay of factors, including excessive workload, insufficient staffing, limited time,

inadequate training, and the absence of clear protocols or standardized pathways; in addition, deep sedation, hemodynamic instability, and concerns about patient safety are frequently cited as major barriers.[18,19]

Despite multiple reviews and guidelines, an integrated synthesis identifying optimal timing, modality, and safety standards for early exercise remains lacking. Against this backdrop, the present study targets critically ill individuals at elevated risk for ICUAW, providing a rigorous and updated synthesis of the evidence to inform optimal clinical strategies for prevention and management.

Recognizing these gaps and challenges, this study centers on critically ill ICU patients and systematically addresses barriers to early exercise. By rigorously reviewing relevant domestic and international literature, we employ evidence-based methodologies to summarize the most current evidence regarding prevention, intervention, and management of early exercise in ICU populations. The derived findings are translated into clinical context, thus supporting the development of scientifically grounded, evidence-based protocols for early exercise interventions in this patient population.

Methods

Identification of the Evidence-Based Issues

The PIPOST tool, developed by the Center for Evidence-Based Nursing at Fudan University, was utilized to formulate the specific evidence-based practice questions.[20] Components were established as follows: (1) P (Population): Critically ill adult patients; (2) I (Intervention): Various forms of early exercise intervention; (3) P (Professionals): Healthcare professionals responsible for implementation; (4) O (Outcome): Incidence of ICUAW, muscle strength, ability to perform activities of daily living, length of ICU and hospital stay, and duration of mechanical ventilation; (5) S (Setting): Intensive Care Unit (ICU); (6) T (Type of evidence): Sources included clinical guidelines, clinical decision tools, expert consensus statements, systematic reviews, meta-analyzes, randomized controlled trials, and original research articles.

In this review, early exercise interventions were operationally divided into two categories: (1) mobilization, defined as functional positional and ambulation progressions (eg, bed mobility, sitting at the edge of the bed, standing, and walking); and (2) exercise, defined as structured strength and/or endurance modalities (eg, resistance training, cycle ergometry, and neuromuscular electrical stimulation).[21,22]

Literature Retrieval Method

Following the "6S" evidence hierarchy, systematic searches were conducted in multiple databases and platforms, including BMJ Best Practice, UpToDate, Joanna Briggs Institute (JBI), Society of Critical Care Medicine (SCCM), National Institute for Health and Care Excellence (NICE), American Thoracic Society (ATS), American College of Chest Physicians (CHEST), Cochrane Library, PubMed, Embase, Web of Science, Physiotherapy Evidence Database (PEDro), CINAHL, CNKI, Wanfang, Weipu, and Sinomed. English search terms included:

> ICUAW / ICU acquired weakness / intensive care unit-acquired weakness / critical illness polyneuropathy / CIP / critical illness myopathy / critical illness polyneuropathy / critical illness neuromuscular abnormality / CIM / ICU-acquired weakness / intensive care unit acquired weakness / ICUAW

combined with intervention and management terms such as

> intervention*, management, prevent*, exercise*, exercise therapy, physical therapy modality*, occupational therapy, exercise train*, exercise intervention*, physical therapy, early exercise*, early mobilization, early activity*, exercise rehabilitation,

and study type descriptors including "guideline*practice guideline, randomized controlled trials, recommended practice, consensus*meta-analysis, systematic review."

This study was registered with the Center for Evidence-Based Nursing at Fudan University (Registration Number: ES20257998), and the registration certificate is available in Appendix A. The literature search period extended from database inception through April 30, 2025. Search strategies were tailored to each database's syntax and indexing conventions. Details of the PubMed search strategy are presented in Table 1. Other search strategies for the remaining databases are provided in Appendix B.

Table 1 PubMed Search Strategy

#1	(("intensive care units"[MeSH Terms]) OR ("critical illness"[MeSH Terms])) OR ("critical care"[MeSH Terms]))
#2	(("ICU"[Title/Abstract]) OR ("critically ill"[Title/Abstract])) OR ("care units*"[Title/Abstract]))
#3	("muscle weakness"[MeSH Terms]) OR ("neuromuscular disease*"[MeSH Terms])
#4	(("ICU acquired weakness"[Title/Abstract]) OR ("ICUAW"[Title/Abstract])) OR ("intensive care unit acquired weakness"[Title/Abstract]))
#5	((Exercise*[MeSH Terms]) OR ("Exercise Therapy"[MeSH Terms])) OR ("Physical Therapy Modalit*"[MeSH Terms]))
#6	((((((((((("Exercise Train*"[Title/Abstract]) OR "Early Exercis*"[Title/Abstract])) OR (" Intervention*"[Title/Abstract])) OR ("Physical Therapy"[Title/Abstract])) OR ("Early mobilization"[Title/Abstract])) OR ("Early activit*"[Title/Abstract])) OR ("Exercise Rehabilitation"[Title/Abstract]) OR (management [Title/Abstract]) OR ("prevent*"[Title/Abstract]) OR ("occupation therapy"[Title/Abstract])
#7	(((((Systematic review[Title/Abstract]) OR (meta-analysis[Title/Abstract])) OR (guideline[Title/Abstract])) OR (consensus[Title/Abstract])) OR (randomized controlled trials[Title/Abstract])
#8	#1 OR #2
#9	#3 OR #4
#10	#5 OR #6
#12	#7 AND #8 AND #9 AND #10

Notes: #: Indicates the search step number and is used for logical combinations (eg, #1 OR #2). *: Serves as a wildcard, representing any characters following the listed term (eg, "exercise*" includes "exercise," etc).

Literature Inclusion and Exclusion Criteria

Inclusion criteria were defined as: (1) subjects aged 18 years or older with critical illness; (2) studies investigating prevention, intervention, or management of early exercise within the ICU setting; (3) literature consisting of clinical guidelines, expert consensus, systematic reviews, randomized controlled trials, or clinical recommendations; (4) publications in either English or Chinese; and (5) for revised or updated guidelines/consensus documents, the most current edition was selected.

Exclusion criteria comprised: (1) articles lacking available full text; (2) duplicated publications; (3) conference abstracts, draft manuscripts, or incomplete fragments; (4) publications in languages other than Chinese or English; and (5) studies with insufficient methodological quality or scientific rigor.

Literature Screening

All records initially identified were imported into Note Express 4.0, where duplicate entries were removed. Two investigators with training in evidence-based medicine then independently conducted the literature screening. Titles, abstracts and keywords were examined in the first round, followed by a second round based on full-text review and methodological quality appraisal. When disagreement arose about whether a study should be included, a third senior expert in evidence-based nursing was consulted, and the final decision was reached through group discussion.

Literature Quality Evaluation

Different quality appraisal tools were employed according to evidence type: (1) For clinical guidelines, the 2017 AGREE II instrument was applied;[23] (2) The methodological robustness of the included systematic reviews was appraised using the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews 2) instrument;[24] (3) For randomized controlled trials, risk of bias was independently assessed at the outcome level using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2), focusing on bias arising from the randomization process, deviations from intended interventions, missing outcome data, and selective reporting of results;[25](4) Expert consensus statements were assessed using the Australian JBI Center for Evidence-Based Health Care's Quality Assessment Criteria (2016).[26]

Methodological quality assessment of all included literature was independently conducted by two researchers. In cases of discrepant evaluations, a third researcher was consulted to mediate the disagreements. The Intraclass Correlation Coefficient (ICC) was employed to assess inter-reviewer agreement among the evaluators. Where inconsistencies existed among the conclusions of different evidence sources, the highest-quality and most recently published evidence from peer-reviewed authoritative journals was prioritized.

Evidence Synthesis and Grading

Two independent reviewers critically assessed each study, determined evidence levels, and synthesized core themes. Any discrepancies were addressed by consensus among the research team. In cases of differing interpretations across sources, preference was given to primary data, high-quality studies, and the latest authoritative publications.

The strength of evidence was appraised using the 2016 JBI Center for Evidence-Based Health Care grading system, ranking evidence from Level 1 (highest) to Level 5 (lowest) according to study design. Recommendations were graded A (strong) or B (weak) based on the FAME framework—feasibility, appropriateness, meaningfulness, and effectiveness. For evidence synthesized from multiple sources, the highest-grade evidence was used to establish the final recommendation level.

Quantitative Synthesis of Key Clinical Outcomes

In addition to the narrative synthesis, we constructed a summary table of key quantitative effects for outcomes judged to be most clinically relevant for ICUAW prevention (incidence of ICUAW, duration of mechanical ventilation, ICU and total hospital length of stay, functional status, delirium, and adverse events). For each outcome, we preferentially extracted pooled effect estimates (eg odds ratios [ORs], risk ratios [RRs], mean differences [MDs], or weighted mean differences [WMDs] with 95% confidence intervals) from high-quality systematic reviews and meta-analyzes included in this review. When multiple systematic reviews reported overlapping meta-analyzes for the same outcome, we selected the most recent and/or methodologically robust review with the largest and most comprehensive sample. If no pooled analysis was available for a given outcome, effect sizes were taken from the largest or highest-quality randomized controlled trial.

Results

General Information on the Included Literature

Initially, 8,755 records were retrieved and imported into NoteExpress 4.0 software. After the removal of 564 duplicates, 7,824 studies were eliminated following title and abstract screening. Ultimately, after full-text assessment and quality evaluation, 24 studies met the inclusion criteria for further analysis. The detailed literature selection process is outlined in Figure 1.

General Characteristics of the Included Articles

The 24 included sources consisted of 6 clinical guidelines,[27–32] 8 randomized controlled trials,[22,33–39] 7 systematic reviews,[4,40–45] and 3 expert consensus statements.[21,46,47] Extracted details include author, article title, year of publication, source, type, and thematic focus. These are presented in Table 2.

Quality Evaluation of Included Literature

In the methodological quality appraisal of all studies included in the current investigation, the ICC derived from the two independent assessors was > 0.750, confirming superior inter-assessor consistency and high methodological reliability between the two reviewers.

Quality Evaluation Results of the Guidelines

Six clinical guidelines were appraised, and summary results are presented in Table 3.

Quality Evaluation Results of Randomized Controlled Trials

Eight randomized controlled trials were evaluated for methodological quality; these results are summarized in Table 4.

Quality Evaluation Results of Systematic Reviews

Seven systematic reviews underwent quality evaluation, with results detailed in Table 5.

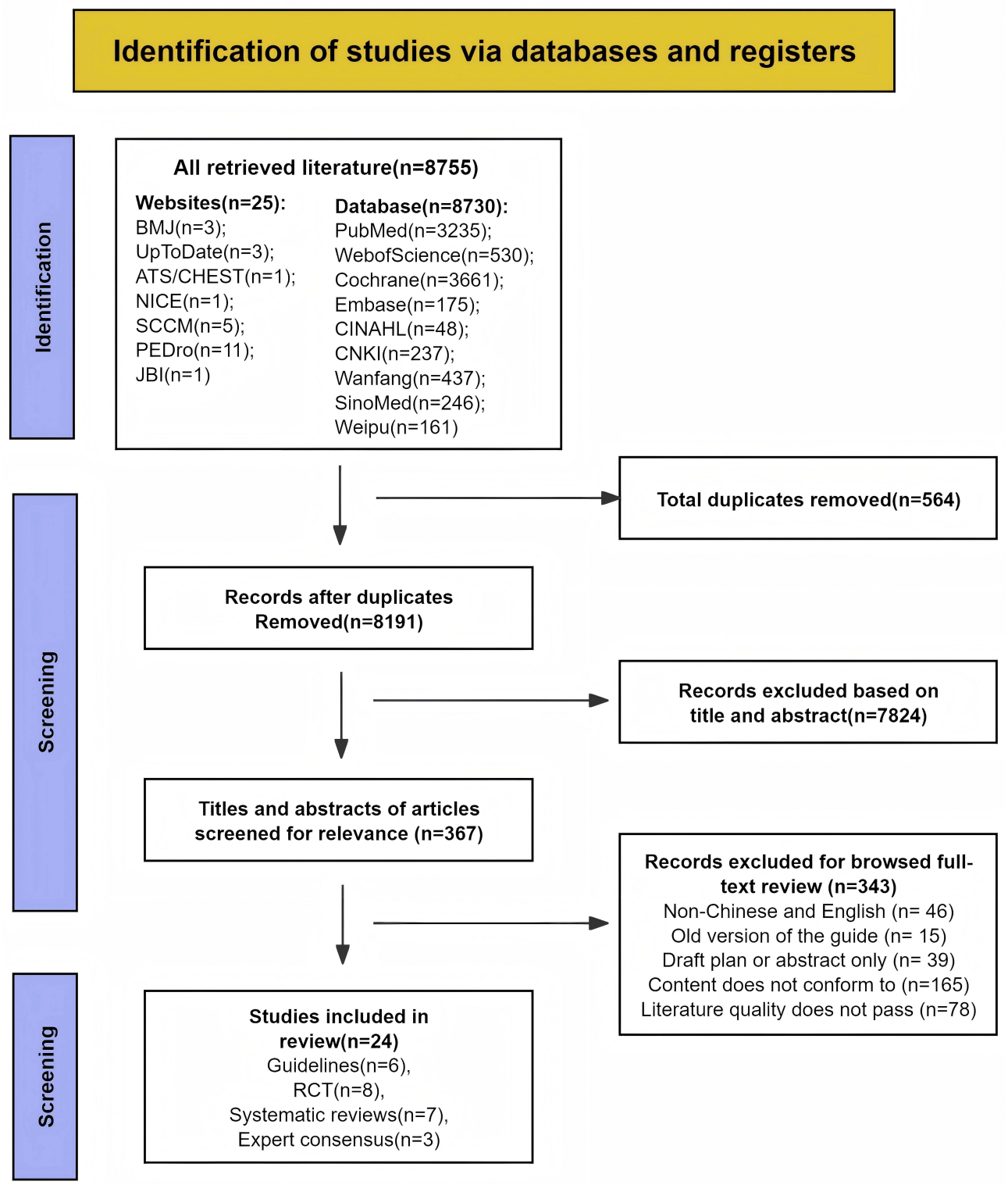


Figure 1 Screening flow chart for included literature.
Abbreviations: BMJ, BMJ Best Practice; JBI, Joanna Briggs Institute; SCCM, Society of Critical Care Medicine; NICE, National Institute for Health and Care Excellence; ATS, American Thoracic Society; CHEST, American College of Chest Physicians; PEDro, Physiotherapy Evidence Database; CINAHL, Cumulative Index to Nursing and Allied Health Literature; CNKI, China National Knowledge Infrastructure.

Table 2 General Information of the Included Literature

Included Literature	Literature Source	Year of Publication	Document Type	Literature Topics
NICE[27]	PubMed	2009	Guideline	Rehabilitation after critical illness in adults.
ATS[28]	PubMed	2014	Guideline	An Official American Thoracic Society Clinical Practice Guideline: The Diagnosis of Intensive Care Unit–acquired Weakness in Adults.
Green M et al[30]	PubMed	2016	Guideline	Mobilization of intensive care patients: a multidisciplinary practical guide for clinicians.
Aquim EE et al[29]	PubMed	2019	Guideline	Brazilian Guidelines for Early Mobilization in Intensive Care Unit.
Renner C et al[31]	PubMed	2023	Guideline	Guideline on multimodal rehabilitation for patients with post-intensive care syndrome.
Unoki T et al[32]	PubMed	2023	Guideline	Japanese Clinical Practice Guidelines for Rehabilitation in Critically Ill Patients 2023 (J-ReCIP 2023).
Schujmann DS et al[33]	PubMed	2020	RCT	Impact of a Progressive Mobility Program on the Functional Status, Respiratory, and Muscular Systems of ICU Patients: A Randomized and Controlled Trial.
Zhou W et al[34]	PubMed	2022	RCT	Effect of early mobilization combined with early nutrition on acquired weakness in critically ill patients (EMAS): A dual-center, randomized controlled trial.
Patel BK et al[35]	PubMed	2014	RCT	Impact of Early Mobilization on Glycemic Control and ICU-Acquired Weakness in Critically Ill Patients Who Are Mechanically Ventilated.
Lu YX et al[36]	CNKI	2024	RCT	Improvement of Early Exercise Combined with Electrical Stimulation of the Neuromuscular System on ICU-Acquired Weakness in Patients with Severe Pneumonia.
Schweickert WD et al[22]	PubMed	2009	RCT	Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomized controlled trial.
Kayambu G et al[37]	PubMed	2015	RCT	Early physical rehabilitation in intensive care patients with sepsis syndromes: a pilot randomized controlled trial.
Schaller SJ et al[38]	PubMed	2016	RCT	Early, goal-directed mobilization in the surgical intensive care unit: a randomized controlled trial.
Eggmann S et al[39]	PubMed	2018	RCT	Effects of early, combined endurance and resistance training in mechanically ventilated, critically ill patients: A randomized controlled trial.
Wang R et al[40]	CNKI	2021	Systematic Review	A Meta-analysis on the Application Effect of Early In-Bed Cycling Exercise in ICU Mechanically Ventilated Patients.
Zhang L et al[41]	PubMed	2019	Systematic Review	Early mobilization of critically ill patients in the intensive care unit: A systematic review andmeta-analysis.
Menges D et al[42]	PubMed	2021	Systematic Review	Systematic early versus late mobilization or standard early mobilization in mechanically ventilated adult ICU patients: systematic review and meta-analysis.
Garcia-Perez-de-Sevilla G et al[43]	PubMed	2022	Systematic Review	Effectiveness of physical exercise and neuromuscular electrical stimulation interventions for preventing and treating intensive care unit-acquired weakness: A systematic review of randomized controlled trials.
Wang J et al[44]	PubMed	2020	Systematic Review	Effects of early mobilization on the prognosis of critically ill patients: A systematic review and meta-analysis.
Anekwe DE et al[48]	PubMed	2020	Systematic Review	Early rehabilitation reduces the likelihood of developing intensive care unit-acquired weakness: a systematic review and meta-analysis.
Ruo Yu L et al[45]	PubMed	2024	Systematic Review	Optimal timing for early mobilization initiatives in intensive care unit patients: A systematic review and network meta-analysis.
Hodgson CL et al[21]	PubMed	2014	Expert consensus	Expert consensus and recommendations on safety criteria for active mobilization of mechanically ventilated critically ill adults.
Raurell-Torredà M et al[46]	PubMed	2021	Expert consensus	Early mobilization algorithm for the critical patient. Expert recommendations.
Sommers J et al[47]	PubMed	2015	Expert consensus	Physiotherapy in the intensive care unit: an evidence-based, expert-driven, practical statement and rehabilitation recommendations.

Abbreviations: ATS, American Thoracic Society; NICE, National Institute for Health and Care Excellence.

Quality Evaluation Results of Expert Consensus

Three expert consensus statements were evaluated, with findings reported in Table 6.

Summary and Generation of Evidence

Through the systematic organization and synthesis of thematically related content, a total of 36 pieces of evidence were identified and categorized into eight thematic domains: Exercise effectiveness, Exercise assessment, Exercise risk management, Exercise form, Exercise intensity, Exercise prescription, Exercise safety, Exercise supervision. Building on the JBI levels

Table 3 Methodological Quality Evaluation Results of the Guidelines

Included Literature	Percentage of Standardization in All Domains						≥ 60% of the Number of Fields	≥ 30% of the Number of Fields	Recommended Level
	Scope and Purpose	Participants	Rigor of Formulation	Clarity of Presentation	Usefulness of the Guide	Editorial Independence			
NICE[27]	81.00	85.71	82.14	76.19	46.43	21.43	4	1	B
ATS[28]	76.19	71.43	71.43	81.00	67.86	71.43	6	0	A
Green M et al[30]	66.7	53.3	63.75	70	57.5	70	4	2	B
Aquim EE et al[29]	76.19	61.9	58.92	57.14	46.43	42.8	2	4	B
Renner C et al[31]	76.19	66.6	57.1	42.85	42.85	71.4	3	3	B
Unoki T et al[32]	81.00	61.86	76.86	85.71	60.71	28.57	5	0	B

Notes: The standardized domain percentage was calculated as (domain score/domain maximum × 100%). Domains achieving ≥30% suggest general applicability, and those with ≥60% indicate high quality and strong recommendation for use. Overall quality was rated 1–7 points (7 being optimal), and the final guideline recommendation grading (eg, "Grade A") reflects methodological rigor and clinical applicability.
Abbreviations: ATS, American Thoracic Society; NICE, National Institute for Health and Care Excellence.

Table 4 RoB2 (Revised Cochrane Risk of Bias Tool for Randomized Trials) for RCTs

Literature Review Items were Included	①	②	③	④	⑤	⑥	⑦
Schujmann DS et al[33]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Zhou W et al[34]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Patel BK et al[35]	Low Risk	Low Risk	Low Risk	Unclear	Low Risk	Low Risk	Unclear
Lu YX et al[36]	Low Risk	Unclear	Low Risk	Unclear	Low Risk	Low Risk	Unclear
Schweickert WD et al[22]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Kayambu G et al[37]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Schaller SJ et al[38]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk
Eggmann S et al[39]	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk	Low Risk

Notes: ①Random sequence generation; ②Allocation concealment; ③Blinding of participants and personnel; ④Blinding of outcome assessment; ⑤Incomplete outcome data; ⑥Selective reporting; ⑦Other sources of bias.

Table 5 AMSTAR 2 (A MeaSurement Tool to Assess Systematic Reviews 2) for Systematic Reviews and Meta-Analyzes

Items	Wang R et al[39]	Zhang L et al[40]	Menges D et al[41]	Garcia-Perez-de-Sevilla G et al[42]	Wang J et al[43]	Anekwe DE et al[44]	Ruo Yu L et al[48]
PICO	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Protocol	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes
Included criteria	No	No	No	No	No	No	No
Comprehensive search	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes	Partial Yes
Duplicate selection	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Duplicate Data Extraction	Yes	Yes	Yes	Yes	Yes	Yes	Yes
List of excluded studies	Partial Yes	Yes	Yes	Yes	Yes	Partial Yes	Partial Yes
Description of included studies	Partial Yes	Partial Yes	Partial Yes	Yes	Yes	Yes	Yes
Assess ROB	Yes	Yes	Partial Yes	Yes	Yes	Yes	Partial Yes
Funding of included studies	No	No	No	No	No	No	No
Statistical Combination of Results	Yes	Yes	Yes	No meta-analysis	Yes	Yes	Yes
Assess ROB Impact on Statistical Combination	No	Yes	No	No meta-analysis	No	No	No
ROB in the Discussion	No	Yes	Yes	Yes	No	Yes	Yes
Discussion for the Heterogeneity	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Publication Bias Impact	No	Yes	No	Yes	No	Yes	Yes
Conflict of Interest, Funding	No	Yes	Yes	Yes	Yes	Yes	Yes

Abbreviations: PICO, patient/population, intervention, comparison, outcomes; ROB, risk of bias.

Table 6 Quality Evaluation of Expert Consensus Documents

Evaluation of Entries	①	②	③	④	⑤	⑥
Hodgson CL et al[21]	YES	YES	YES	YES	YES	YES
Raurell-Torredà M et al[46]	YES	YES	YES	YES	YES	YES
Sommers J et al[47]	YES	YES	YES	YES	YES	YES

Notes: ① Whether a clear source of point of view is presented? ② Whether the opinion comes from influential experts in the field? ③Whether the arguments presented are centered on the interests of the people involved in the study? ④Whether the stated conclusions are based on the results of the analysis? ⑤Whether other existing literature has been consulted and accurately indexed? ⑥Whether there are any inconsistencies between the points presented and previous literature?

of evidence (1a–5c), we applied an explicit upgrading and downgrading logic when grading recommendations. When the evidence was of high level (eg, 1a/1b), multiple studies demonstrated consistent direction and stable effect sizes with clear clinical relevance, and no major sources of bias or safety concerns were identified, the recommendation was Graded as A, or upgraded from a provisional Grade B to A. Conversely, when the evidence was primarily derived from lower-level studies or expert consensus, with limitations in methodological quality or consistency of findings, and when the anticipated benefits needed to be carefully weighed against potential risks and resource consumption, the recommendation was Graded as B, or downgraded from a provisional Grade A to B. The detailed evidence summary is presented in Table 7.

Table 7 Specific Content of Evidence Summary

Project	Summary of Evidence	Evidence Level	Recommendation Level	RoB	Reference IDs
Exercise effectiveness	Early exercise intervention is safe and feasible for the prevention of ICUAW in ICU patients.	1a	A	Low	[38,41,42,44,48]
	Early motor intervention can relieve patients' fear, reduce psychological pressure, and promote active cooperation.	1a	A	Low	[28,31,32,34]
	Exercise intervention can maintain muscle strength, improve cardiopulmonary circulation, improve self-care ability, improve prognosis, and shorten ventilation and hospital stay.	1a	A	Low	[33,41,43,48,49]
Exercise assessment	All patients were assessed by a multidisciplinary team within 24 hours of admission to the ICU, and early movement was recommended for mechanical ventilation patients within 24–72 hours.	1a	B	Low	[22,28,45]
	Muscle strength assessment: It is recommended to routinely monitor ICUAW in high-risk ICU patients, conduct a clinical evaluation as early as possible, and use the MRC score as a tool for muscle strength test and diagnosis of ICUAW. When necessary, a handheld dynamometer can be used as an auxiliary tool.	5b	A	Low	[28,37,41,43,45]
	Thrombus assessment: Assess whether the patient has a history of venous thrombo embolism (VTE). If venous thrombosis occurs, exercise intervention should be avoided in the affected limb.	5b	A	Low	[21,29,36,41]
	Blood glucose assessment and control: daily blood glucose measurement and maintenance of blood glucose level at 6–10mmol/L.	5b	A	Medium	[28,31,35]

(*Continued*)

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Table 7 (Continued).

Project	Summary of Evidence	Evidence Level	Recommendation Level	RoB	Reference IDs
	Daily living ability assessment: BI is used to assess daily living ability once a day.	5b	A	Low	[27,31,34,45]
	Activity level assessment: IMS scores are routinely used to assess the adaptive level of activity to ensure that patients achieve the highest possible level of activity daily.	5b	B	Low	[22,28,41,45,47]
	Sedation assessment and mental state assessment: sedation level is assessed using the RASS score at admission; sedation depth is continuously assessed after sedation is administered; and mental state is assessed using the CAM-ICU scale.	5b	B	Low	[22,30,32,39,47]
	Psychological assessment: it is suggested to use the HADS scale to evaluate the psychological function of patients.	5b	B	Medium	[31,32,37]
Exercise risk management	It is recommended to use the traffic light system of red and green lights for clinical decision-making: Red alert: activities should be suspended when there are high-risk adverse events or serious complications; Yellow alert: restricted activities should be carried out cautiously after multidisciplinary team evaluation; Green permission: systematic exercise training is allowed when all safety parameters are met.	5b	A	Medium	[21,27,29,30,46]
	It is recommended that active exercise training be considered when the RASS score of patients is between −1 and 1.	5b	B	Medium	[27,30,32,41]
	The use of endotracheal intubation and vasopressor drugs is not an absolute contraindication for early exercise, which requires individualized evaluation.	1a	A	Low	[21,22,27,29,30,37,47]
	Active bleeding and uncontrolled thrombotic diseases (deep vein thrombosis/pulmonary embolism) are listed as contraindications.	1a	A	Low	[21,27,29,37,42,44]
	Safety standards for mechanical ventilation: Oxygenation index: FiO_2≤60% and SpO_2≥90%; Ventilation parameters: respiratory rate≤30 times/min, PEEP≤10cmH_2O.	5b	A	Medium	[21,27,29,46]
	Circulatory system standard: Heart rate range: 40–120 times/min; Blood pressure control: systolic blood pressure 90–180mmHg, diastolic blood pressure less than or equal to 100mmHg; Intravenous perfusion index: MAP maintained at 65–110mmHg.	5b	A	Medium	[21,27,29,46]
Exercise form	According to the increase of the condition, the goals of each stage are gradually carried out, including passive, active assisted, active, and resistance exercises.	1c	A	Low	[30,33,34,38,39,47]
	It is recommended that patients should implement muscle electrical stimulation and/or bicycle riding as soon as possible after the stabilization of vital signs.	1a	B	Low	[27,30,40,43]
Exercise intensity	The intensity and content of exercise are determined according to the actual situation of patients, and the plan is determined after evaluation by a multidisciplinary team.	5b	A	Low	[22,30,33,36,38]

(*Continued*)

Table 7 (Continued).

Project	Summary of Evidence	Evidence Level	Recommendation Level	RoB	Reference IDs
	For patients with active movement, a Borg score of 11–13 is recommended.	5b	B	Medium	[29,42,47]
	Conduct progressive mobility activities following the forward chaining principle (patients must complete the current stage before advancing to the next).	1c	A	Low	[32,35,36,38]
Exercise prescription	For patients with impaired consciousness, it is recommended to perform passive movement of the upper limbs, auxiliary circulation dynamometer training, neuromuscular electrical stimulation of the lower limbs, and passive body position change at the same time.	1c	A	Low	[30,32,33,43,48]
	For patients with conscious consciousness and muscle strength <3, it is recommended to carry out auxiliary training for the upper limbs, assisted circulation dynamometer training, and neuromuscular electrical stimulation for the lower limbs, and at the same time carry out assisted body position change in bed, assisted sitting up in bed, trunk exercise, etc.	1c	A	Low	[33,36,48]
	For patients with consciousness and muscle strength of grade 3 or above, it is recommended to carry out auxiliary training and resistance training for the upper limbs, assistive cyclic force gauge training and neuromuscular electrical stimulation for the lower limbs, and carry out the active transfer from bed to sit and from sitting to stand at the same time.	1c	A	Low	[22,33,38,39]
	For patients with consciousness and muscle strength>5, it is recommended to carry out resistance training for upper and lower limbs as the main, assisted active cyclic force gauge training, and at the same time, active bedside sitting up, standing, and/or walking training, stepping training, sitting balance training, etc.	1c	A	Low	[33,35,37,39]
	Final goal: resistance training of upper and lower limbs to achieve and maintain sitting up and standing at the bedside without assistance.	1a	B	Low	[22,35,38,39]
Exercise safety	Closely monitor the vital signs of patients during exercise, observe the changes in condition, and start and end intervention according to exercise safety standards and stop criteria.	1a	A	Low	[21,29,33,41,44]
	In patients undergoing invasive mechanical ventilation who experience respiratory discomfort and/or patient-ventilator asynchrony during early exercise, the ventilator should be adjusted to achieve better synchrony.	5b	A	Low	[21,29,30,36]
	For patients on enteral nutrition, eating should be stopped during exercise to prevent aspiration.	5b	B	Medium	[27,30,34]
	For patients receiving intermittent CRRT, anticoagulation measures should be monitored before and after treatment to ensure the safety and effectiveness of treatment.	5c	B	High	[27,28]

(*Continued*)

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Table 7 (Continued).

Project	Summary of Evidence	Evidence Level	Recommendation Level	RoB	Reference IDs
Exercise supervision	Medical institutions and sports training-related sites should be equipped with various monitoring equipment, and emergency plans should be made to ensure the safety of exercise.	5b	A	Medium	[21,30,47]
	The level of activity should be determined by the patient's strength and endurance, as well as an assessment of safety standards.	1a	A	Low	[22,30,38,47]
	The multidisciplinary team in the ICU evaluates patients, develops personalized early rehabilitation programs, emphasizes safety and team decision-making, and promotes the functional recovery of critically ill patients.	1c	A	Low	[29–31,38,47]
	Humanistic care should be provided through psychological counseling and family participation in decision-making to help patients build confidence and improve treatment compliance.	5b	A	Medium	[30–32]
	Movement assessment and implementation begins during ICU stay, until discharge from the ICU, until general ward, until discharge to general ward or community, and at least six weeks after discharge, with follow-up after discharge.	5b	A	Medium	[27,31,32]

Abbreviations: RoB, risk of bias; ICUAW, intensive care unit–acquired weakness; ICU, intensive care unit; MRC, Medical Research Council sum score; VTE, venous thromboembolism; BI, Barthel Index; IMS, ICU Mobility Scale; RASS, Richmond Agitation–Sedation Scale; CAM-ICU, Confusion Assessment Method for the Intensive Care Unit; HADS, Hospital Anxiety and Depression Scale; FiO2, fraction of inspired oxygen; SpO2, peripheral oxygen saturation; PEEP, positive end-expiratory pressure; MAP, mean arterial pressure; Borg score, Borg Rating of Perceived Exertion scale; CRRT, continuous renal replacement therapy.

Quantitative Synthesis of Key Clinical Outcomes

By synthesizing best-available effect estimates from high-quality systematic reviews and randomized controlled trials with a low risk of bias, a total of seven studies were included (four systematic reviews[41,42,45,48] and two randomized controlled trials).[33,38] Effect estimates were integrated to evaluate how intervention timing and rehabilitation modality influence key outcomes, including the incidence of ICUAW, ICU length of stay and total hospital length of stay, activities of daily living (Barthel Index), and delirium-related outcomes. Detailed results are presented in Table 8.

Discussion

Emphasizing the Importance of Early Identification and Comprehensive Assessment in ICUAW Management

Early identification and systematic comprehensive assessment are critical foundations for effective rehabilitation in the intensive care unit (ICU). Timely initiation of early exercise is essential to reduce the risk of intensive care unit acquired weakness (ICUAW) and minimize associated complications.[49] However, there remain significant deficits in the early recognition and evaluation of ICUAW. For example, a large-scale, multicenter cross-sectional survey indicated that only 19% of ICU clinical staff actively screen their patients for ICUAW, and only 12% employ dedicated tools such as the Medical Research Council (MRC) score for assessment, with most relying on clinical judgment alone.[50] Current evidence highlights the necessity for multidisciplinary teams (MDTs) to assess all patients within the first 24 hours of ICU admission. Evidence 4,5 emphasizes that physical therapy should ideally commence within 24–72 hours for patients receiving mechanical ventilation. It is recommended that high-risk ICU patients undergo ongoing muscle strength monitoring utilizing the MRC score, which remains the primary standardized instrument for assessment and diagnosis of ICUAW. Additional devices, such as hand-held dynamometers, may be used as appropriate. Comprehensive patient

Table 8 "Key Effects" Summary Table

Key Outcome Measures	Stratification Criterion	Intervention	Comparator	Effect Size (95% CI)
Incidence of ICUAW	By time of intervention initiation	Initiated within ≤72 hours	Usual care	RR = 0.70 (0.50, 0.97)
		Initiated after >72 hours	Usual care	RR = 0.75 (0.42, 1.35)
		Systematic early (Initiated within 7 days)	Standard early Mobilization (Sham intervention or no rehabilitation intervention)	RR = 0.90 (0.63, 1.27)
		Systematic early (Initiated within 7 days)	Late mobilization (Initiated at 7 days or later)	RR = 0.62 (0.38, 1.03)
		≤ 24h	Usual care	RR = 0.44 (0.28, 0.68)
		> 24h	Usual care	RR = 0.33 (0.16, 0.67)
		≤ 72h	Usual care	RR = 0.33 (0.20, 0.52)
		>72h	Usual care	RR = 0.79 (0.29, 2.14)
	By type of rehabilitation intervention	Early mobilization	Usual care	RR = 0.70 (0.49, 1.00)
		NMES	Usual care	RR = 0.68 (0.38, 1.19)
		Early mobilization and NMES	Usual care	RR = 0.96 (0.31, 3.01)
		Mobilization interventions	Standard or usual treatment	RR = 0.60 (0.40, 0.90)
Total length of stay	By time of intervention initiation	≤ 24h	Usual care	WMD = −2.46(−4.35, −0.57)
		> 24h	Usual care	WMD = −4.98 (−8.02, −1.94)
		≤ 72h	Usual care	WMD = −0.63(−5.30, 4.04)
		>72h	Usual care	WMD = −2.96(−6.02, 0.10)
	By type of rehabilitation intervention	Cycling on a cycle ergometer	Standard or usual treatment	SMD = 0.09,(−0.07, 0.26)
		Enhanced or intensive rehabilitation	Standard or usual treatment	SMD = −0.44(−0.99, 0.12)
		Mobilization or rehabilitation	Standard or usual treatment	SMD = −0.46(−1.37, 0.44)
		Physiotherapy intervention	Standard or usual treatment	SMD = −0.85(−1.94, 0.24)
ICU length of stay	By time of intervention initiation	≤ 24h	Usual care	WMD = −3.00(−4.58, −1.42)
		> 24h	Usual care	WMD = −4.70 (−6.70, 2.71)
		≤ 72h	Usual care	WMD = −3.00 (−4.58, −1.42)
		>72h	Usual care	WMD = −2.68 (−4.71, −0.65)
Total length of stay	By time of intervention initiation	≤ 24h	Usual care	WMD = −3.28 (−4.61, −1.95)
		> 24h	Usual care	WMD = −3.61(−5.53, −1.68)
		≤ 72h	Usual care	WMD = −2.10 (−7.54, 3.34)
		>72h	Usual care	WMD = −2.79(−5.06, −0.51)
BI	By time of intervention initiation	≤ 24h	Usual care	WMD = −0.90(−0.71, 2.51)
		> 24h	Usual care	WMD = 2.51 (0.59, 4.42)
		≤ 72h	Usual care	WMD = 1.44(−2.81, 5.69)
		>72h	Usual care	WMD = 1.09(−1.92, 4.10)
	By type of rehabilitation intervention	Early progressive mobilization (including cycling)	Conventional treatment	MD = 21(14.5, 26.3)

(*Continued*)

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Table 8 (Continued).

Key Outcome Measures	Stratification Criterion	Intervention	Comparator	Effect Size (95% CI)
Functional Status				
Independent functional status at discharge		Physical and occupational therapy	Standard care	OR = 2.6 (1.4, 4.8)
SF-36 Physical Health Component Summary Score		Early Mobilization	Standard care	MD = 3.4(0.01, 6.8)
Delirium	By time of intervention initiation	Systematic early (Initiated within 7 days)	Late mobilization (Initiated at 7 days or later)	MD = 12.30(3.85, 20.75)

Abbreviations: CI, confidence interval; ICUAW, intensive care unit–acquired weakness; RR, risk ratio; h, hour(s); NMES, neuromuscular electrical stimulation; WMD, weighted mean difference; SMD, standardized mean difference; ICU, intensive care unit; BI, Barthel Index; MD, mean difference; OR, odds ratio; SF-36, 36-Item Short Form Health Survey.

assessment serves as the prerequisite for the safe initiation of early exercise. Furthermore, recent international surveys identify safety concerns as a major barrier to clinical implementation.[51] In contrast, protocols employing standardized safety guidelines have been shown to enhance early exercise rates in the ICU.[52] Evidence 6–11 emphasizes that given the complex clinical status and multifactorial risk profile of ICU patients, including the specific indications and contra-indications for early exercise, a detailed evaluation should include thrombosis risk, glucose control, activities of daily living (ADL), current physical activity levels, depth of sedation, mental status, and psychological well-being.

In summary, integrating prompt identification with a thorough and systematic assessment constitutes the core process for promoting patient safety and the effective attainment of early rehabilitation goals in the ICU. Mastery of these two components is vital for the success of early exercise protocols targeting ICUAW prevention.

Integrative Synthesis and Clinical Translation

Based on the "Key effects" summary table derived from the high-quality systematic reviews/meta-analyzes and key randomized controlled trials (RCTs) included in this review (Table 8), the overall benefit of early exercise for preventing ICUAW is likely influenced by initiation timing, intervention configuration, and patient subgroup characteristics. With respect to timing, the current evidence broadly supports the principle of earlier initiation.[42] In particular, initiating early exercise within 24–72 hours after ICU admission shows a more consistent pattern of benefit, most notably in shortening the duration of mechanical ventilation and reducing ICU length of stay; some time-stratified analyzes also suggest a potential association with a lower risk of ICUAW.[45,48] When initiation occurs beyond this window, effects generally remain directionally favorable, but statistical significance and effect stability are less consistent, indicating that the optimal threshold remains uncertain.

Regarding intervention strategy, both guidelines and empirical studies tend to support a multimodal, staged, and progressive approach—progressing from passive to active exercise and, where appropriate, supplemented with neuromuscular electrical stimulation (NMES) and bedside cycle ergometry—to enhance muscle preservation and functional recovery.[33,45] However, comparative findings across modalities are not fully consistent. Notably, when NMES alone is compared with NMES combined with active/functional training (including bedside cycling), some analyzes indicate clearer benefits for NMES alone, whereas combined strategies do not consistently outperform usual care. These discrepancies may reflect the complexity and heterogeneity of ICU populations, as well as variability in dose, intensity, fidelity of delivery, and implementation across studies. Evidence remains limited for clinically important subgroups—including mechanically ventilated versus non-ventilated patients, septic versus non-septic populations, and strata defined by sedation depth—and several subgroup estimates are imprecise (wide confidence intervals), precluding firm conclusions.

Accordingly, clinical practice should prioritize an MDT-led, safety-threshold–guided, individualized and progressive early rehabilitation pathway: initiate as early as physiologically feasible, tailor modality and dose dynamically according to tolerance, and iteratively optimize the program through regular reassessment of muscle strength and functional status alongside systematic monitoring of adverse events.

A Stepped Early Exercise Plan Guided by Sequential Progression and Patient-Specific Assessment

Current evidence supports that combining daily neuromuscular electrical stimulation (NMES) with early exercise intervention is well-tolerated by critically ill patients, aids in preserving muscle strength, prevents ICU-acquired weakness (ICUAW), and reduces both the duration of mechanical ventilation and length of ICU stay.[53] Evidence 18 and 19 recommend that underscores the importance of integrating NMES and early exercise as part of routine ICU care, particularly through interventions by intensive care nursing teams. Several guidelines recommend that the modality of exercise be aligned to the patient's clinical course, implementing sequential progression from passive, active-assistive, to active and resistance exercises, with each stage having specific goals. Initiation of physical therapies such as NMES and cycle ergometry should occur as soon as hemodynamic parameters are stable to prevent secondary complications. The overarching principle of early exercise implementation is a phased and graded progression, ensuring interventions match patient tolerance and readiness. Evidence 20–22 advises that further recommended that exercise intensity be individualized according to comprehensive MDT assessments, with targets such as a Borg Rating of Perceived Exertion of 11–13 for patients able to engage actively.

The core elements of effective early exercise protocols in the ICU are an individualized and sequentially progressive approach, intended to systematically restore patient function using evidence-based exercise prescriptions. Considerable heterogeneity exists in the implementation of early exercise, stemming from differences in intervention types and content between ICUs, which challenges the achievement of consistent, significant clinical benefits. Adoption of standardized, progression-based protocols that correctly match patient capacity and safety thresholds at each intervention stage may be essential for optimizing outcomes.[54] Evidence 23–27 recommend a structured four-phase prescription model based on levels of consciousness and muscle strength, strictly supporting a graded progression in patient activity. Ultimately, this approach is designed to prevent ICUAW onset, decrease morbidity, and achieve improved patient prognoses and quality of life.

Objective Quantification and Safety Assurance: Ensuring the Effective Implementation of Early Exercise

In the ICU environment, safeguarding the safety of critically ill patients during early exercise represents the paramount priority. Evidence 12 demonstrates that systematic exercise interventions are only indicated when all patient safety criteria are satisfied. Evidence 13–17 is Key safety considerations in pre-exercise assessment and per-activity monitoring include current medications, vital sign trends, and both absolute and relative contraindications for exercise. Standardized clinical criteria must be met before initiating early rehabilitation activities.[55] Expert consensus guidelines have outlined safety screening protocols, especially for the exercise of mechanically ventilated adult ICU patients, to facilitate active (both in-bed and out-of-bed) activity while minimizing adverse event risk.[56]

Evidence 28–33 further delineates detailed strategies for the safe execution of early exercise interventions. These strategies require vigilant, ongoing clinical surveillance of patient status and strict adherence to designated activation and termination criteria for all activity. For specialized groups or complex scenarios: (1) Mechanically ventilated patients with patient–ventilator dyssynchrony need prompt ventilator adjustment; (2) For patients receiving enteral nutrition, feeding is paused during exercise to reduce aspiration risk; (3) For those on intermittent continuous renal replacement therapy (CRRT), close monitoring of anticoagulation is necessary before and after activity. The setting must be equipped with appropriate monitoring and emergency equipment, and all prescribed interventions should be based on objective assessment of patient-specific muscle strength and endurance. These measures collectively enable the safe and effective delivery of early rehabilitation programs in the ICU.

Multidisciplinary Team (MDT) Collaboration: A Cornerstone for Safe Early Exercise and Enhanced Recovery in the Intensive Care Unit

Multidisciplinary team (MDT) collaboration represents the foundation for implementing early exercise in the modern critical care environment. MDT collaboration substantially improves both therapeutic efficacy and rehabilitation quality by integrating diverse expertise—including that of physicians, physical therapists, nutritionists, mental health professionals, and nursing staff.

The individualized design and delivery of early exercise prescription by MDTs, based on the patient's clinical diagnosis, Medical Research Council (MRC) score, and other validated assessment instruments, constitutes a highly effective intervention strategy.[57]

The contribution of MDTs to early exercise is supported by multiple lines of evidence. Evidence 4 recommends that all patients should be assessed by an MDT as early as possible. During exercise risk management, Evidence 12 suggests a traffic light system has been proposed for MDT-driven decision-making. Evidence 20 advises that exercise type and intensity should be determined according to the patient's unique clinical status, with each plan finalized following comprehensive MDT evaluation. Moreover, Evidence 28 recommends MDTs should continuously monitor patient vital signs and clinical status during activity, initiating and discontinuing interventions according to clear safety initiation and termination protocols. Finally, Evidence 34 suggests personalizing early rehabilitation plans, emphasizing shared decision-making, safety, and the recovery needs of the critically ill, further demonstrates the centrality of MDT collaboration to optimal outcomes.

Randomized controlled trial data indicate that MDT-based cardiopulmonary rehabilitation programs can significantly reduce the risk of ICU-acquired weakness. Intervention group participants exhibited superior restoration of muscle strength, shorter total treatment duration, reduced mechanical ventilation time, mean reduction in overall hospital stay by approximately 113 hours, and abbreviated ICU length of stay by around 247 hours compared to standard care groups.[58]

In summary, MDT collaboration—via integration of specialized assessments, tailored plan development, dynamic safety surveillance, and continuous quality improvement—constitutes the central process for facilitating safe early exercise, optimizing rehabilitation outcomes, and enhancing the level of intensive care for critically ill patients in the ICU.

Conclusion

This study, grounded in an evidence-based nursing paradigm, synthesized 36 recommendations spanning eight thematic domains: the effectiveness of exercise, assessment methods, risk management strategies, exercise modalities, intervention intensity, exercise prescription, safety measures and supervision. Collectively, these data establish a framework for early exercise interventions guided by multidisciplinary team (MDT) collaboration and highlighting initiation within 24–72 hours of ICU admission as a clinically important time window to prevent ICUAW in critically ill adults. However, due to substantial global variability in healthcare infrastructure, economic capacity, and cultural norms, clinicians must undertake a comprehensive evaluation of patient-specific attributes—including disease severity, sedation/analgesia status, vital parameters, and baseline activity level—prior to applying evidence-based recommendations in clinical practice. This comprehensive assessment is essential to deliver more individualized early exercise protocols and optimize clinical efficacy. A limitation of this study is that, because the search was restricted to English- and Chinese-language publications, relevant studies from other regions (such as continental Europe, Latin America, and Australia) may not have been underrepresented, which could affect the geographic representativeness of the evidence base. In future, we expect to develop effective and safe early exercise strategies tailored to different patient subgroups (eg, mechanically ventilated vs non-ventilated patients, infectious vs non-infectious critical illness, and varying levels of sedation). We also encourage future researchers to undertake large-scale, multicenter longitudinal follow-up studies to strengthen the evidence underpinning clinical guidance, to define the optimal dose–response relationship of neuromuscular electrical stimulation (NMES) for ICUAW prevention, and promote international standardization of early exercise and NMES protocols. Collectively, These efforts may help further reduce ICUAW incidence, support functional recovery, improve prognosis, and enhance patient-centered quality of life.

Highlights

(1) Develop an evidence-based early mobility protocol for ICU patients to prevent ICU-AW and improve outcomes.
(2) Establish an evidence-based early mobilization framework to guide clinical practice for ICU healthcare providers.
(3) Thirty-six key findings were extracted and synthesized across eight thematic domains.
Multidisciplinary evidence synthesis using JBI grading ensures clinical applicability.

Data Sharing Statement

All data generated or analyzed during this study are presented within this published article.

Ethics Statement

In this study, all methods were performed in accordance with the relevant guidelines and regulations. Ethics approval and consent to participate are not necessary since our study was a meta-analysis.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no competing interests in this work.

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