Received: 15 June 2024 | Revised: 25 November 2024 | Accepted: 17 January 2025

DOI: 10.1111/nicc.13278

META-ANALYSIS

BACCN Nursing in Critical Care WILEY

Nurse-involved early mobilization in the intensive care unit: A systematic review and meta-analysis

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Abstract

Background: Early mobilization is one proposed strategy for reducing complications and optimizing patient outcomes. Nurses play an essential role in patient monitoring and co-ordination.

Aims: To assess the effects of a nurse-involved early mobilization programme on muscle strength and intensive care unit (ICU) length of stay and identify the components of an early mobilization programme.

Study Design: A systematic review and meta-analysis were conducted. MEDLINE (PubMed), Embase, Cochrane and CINAHL databases were searched. Eligible studies included randomized controlled trials (RCTs) and non-randomized studies of adult ICU patients undergoing early mobilization. The studies were appraised using RoB 2.0 and ROBINS-I tools, and a meta-analysis was performed using Rstudio 2023.06.2.

Results: Nine studies were selected from 943 studies. Four studies involved only ICU nurses, while five involved multidisciplinary teams. Concerns about bias were raised in four RCTs, and two non-randomized studies had moderate bias risk. Interventions involved progressive exercise steps, but none detailed the specific role of nurses. Early mobilization significantly decreased ICU length of stay (95% CI: −3.22, −0.11; $p = .04$), although it did not improve muscle strength (95% CI: −0.86, 0.99; $p = .80$).

Conclusions: Nurse-involved early mobilization was associated with a reduction in ICU stay, although it did not impact muscle strength. The nurses' roles were not specifically defined.

Relevance to Clinical Practice: An analysis of relevant tasks is necessary to clarify the role of nurses in early mobilization and to provide optimal care. Including these roles is crucial in the development of standardized early mobilization.

KEYWORDS
early ambulation, intensive care unit, length of stay, muscle strength, systematic review

1 | INTRODUCTION

Providing care to patients in the intensive care unit (ICU) should prioritize not only for their survival but also for recovery of their daily activities prior to hospitalization.[1] The use of sedative treatments and prolonged bed rest in ICU patients increases their vulnerability to short-term complications, such as reduced mobility, muscle weakness and respiratory complications, as well as delayed complications, such as post-intensive care syndrome and neuropsychological damage.[2–8] All of these increase treatment costs, delay the patient's return to

daily life and adversely affect their overall quality of life.[3] According to previous studies, approximately 62% of patients discharged from the ICU reported symptoms of persistent muscle weakness for up to 10 years, and only 37% of them made a full recovery.[9] As the duration of ICU stay increases, patients face a higher risk of both physical and psychological issues, including an increased risk of infection and the development of mental health problems.[7,57] Studies have shown that longer ICU stays are also linked to increased requirements for mechanical ventilation and a significant increase in mortality rates.[58]

Early mobilization, a phased exercise intervention initiated as promptly as feasible following patient admission, has been suggested to reduce these complications.[10] It is systematically planned and executed according to each patient's condition and is known to prevent ICU-acquired weakness and contribute to better patient outcomes.[11] However, despite the growing interest in early mobilization in the ICU, substantial challenges persist, including insufficient manpower and time constraints.[12–14]

What is known about the topic

- The immobilization of intensive care unit (ICU) patients and prolonged bed rest increase their vulnerability to complications, thereby delaying recovery and compromising their quality of life.
- Early mobilization of critically ill patients has been proposed to mitigate the occurrence of complications.
- Nurses play a crucial role in monitoring vital signs, managing life-support equipment and co-ordinating among health care professionals.

What this paper adds

- This study identifies the components of early mobilization and evaluated the effects of early mobilization on muscle strength and length of ICU stay.
- This research showed that early mobilization intervention helps reduce the length of ICU stay.
- We recommend the development of standardized guidelines for early mobilization practices and definition of the specific roles of the professionals involved in these interventions.

2 | BACKGROUND

A recent systematic review highlighted the advantages of early mobilization and demonstrated its effects in preventing ICU-acquired weakness, reducing the length of ICU and hospital stays, and enhancing physical mobility in the intervention group.[16] Additionally, Higgins et al.[17] reported that early mobilization substantially decreases the duration of mechanical ventilation for ICU patients, compared with standard care. Other studies have emphasized the importance of the role of health care professionals involved in early mobilization, noting that interprofessional co-ordination, communication and teamwork among physicians, physical therapists and nurses are critical for its successful implementation to improve patient outcomes.[18,19]

Nurses play a particularly vital role in this process, as they are the experts who work most closely with patients to facilitate early mobilization. Owing to their constant presence at the patient's bedside, they are pivotal in initiating and implementing early mobilization, thereby improving patient safety and quality of care.[20] Their role involves screening and classifying the overall feasibility of the intervention based on each patient's hemodynamic stability, physical function and other factors.[55] Additionally, they are responsible for analysing and assessing patient safety and potential risk factors during the early mobilization process to prevent the occurrence of risks at an early stage.[21] ICU nurses serve as essential co-ordinators between patients and the medical teams, as well as between patients and their families.[22] Moreover, they actively participate in training medical staff and patients to carry out early mobilization.[23] However, there is a paucity of reviews focusing on nurse involvement in early mobilization, as well as a lack of comprehensive reviews summarizing its types and components. Therefore, this study focused on nurse-involved early mobilization interventions.

3 | AIMS AND OBJECTIVES

This systematic review aimed to determine whether implementing a nurse-involved early mobilization programme for adult ICU patients leads to a shorter ICU stay or an increase in muscle strength, compared with standard care. The specific objectives were to (a) assess the effects of an early mobilization programme on muscle strength and length of ICU stay and (b) identify the components of the nurse-involved early mobilization programme.

4 | DESIGN AND METHODS

This systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 reporting guidelines.[24]

4.1 | Search strategy

A systematic search of the MEDLINE (PubMed), Embase, Cochrane Central Register of Controlled Trials (CENTRAL) and Cumulative Index to Nursing and Allied Health (CINAHL) electronic databases was conducted on 20 October 2023. The search query was formulated using a combination of Medical Subject Headings (MeSH) terms, keywords and Boolean operators based on consultations with a qualified medical librarian. The key search terms were listed as follows: (1) "Intensive care unit" or "Critical care unit" or "Critically illness" or "ICU", (2) "Rehabilitation" or "Mobilization" or "Early ambulation" and (3) "Nurse-led" or "Nurse initiate*" or "Rehabilitation nursing" or "Nursing intervention" or "Nursing program" or "Nursing therapy".

There were no restrictions regarding publication year. We conducted a manual search of the Google Scholar database to identify additional relevant articles. A summary of the search strategies is provided in Appendix A.

4.2 | Eligibility criteria

The eligibility criteria were determined based on the Population, Intervention, Comparison, Outcomes, and Study design (PICOS) framework.[43]

The inclusion criteria comprised studies involving adult patients admitted to the ICU; studies that compared nurse-involved early mobilization with standard nursing care; studies that presented outcomes, such as muscle strength and length of ICU stay; and studies that used quantitative study designs (RCTs and non-randomized trials). The definition of nurse involvement in early mobilization refers to nurses performing early mobilization either independently or in collaboration with other professionals.

The exclusion criteria encompassed studies that did not report the participation of nurses in early mobilization; involved patients admitted to wards, outpatient clinics and nursing homes; combined early mobilization with other interventions, such as neuromuscular electrical stimulation; were not published in English; or were review articles or grey literature (e.g. conference abstracts, posters and protocol reports).

We included muscle strength and ICU stays as outcome variables to measure the effect of early mobilization in ICU patients. Additionally, we analysed various other variables that can be evaluated as outcomes of early mobilization interventions as secondary outcome variables.

4.3 | Study selection

One researcher (JL) exported the details of all studies to EndNote 20 and removed duplicates. Both researchers (JL and YK) independently screened the titles and abstracts for eligibility and subsequently reviewed the full texts. In cases of discrepancies, agreement was reached through discussion and consultation with a third researcher (HL).

4.4 | Data extraction

Two researchers (JL and YK) independently extracted data from the selected studies. The datasheet format was created according to the study and participants, intervention and outcome characteristics. The study and participant characteristics were first author name, publication year, country, study design, sample size, participant age and sex, primary diagnoses and use of mechanical ventilation. The intervention characteristics comprised intervention provider, name of the intervention, detailed contents of interventions, time of initiation, intervention duration, intervention time (intervention dose) and staff training. Finally, outcome characteristics on key outcome variables and findings were extracted. A third researcher reviewed and confirmed the final extracted data.

4.5 | Quality appraisal

The quality of included RCTs was evaluated using the RoB 2.0 tool, which assesses the risk of bias across five domains.[25] Non-randomized studies were evaluated using the ROBINS-I tool, which assesses the risk of bias across seven domains.[26] The robvis tool was used to create risk-of-bias plots.[27]

Two researchers (JL and YK) independently evaluated the bias in each study. Before evaluating the overall risk of bias across all included articles, we conducted a pilot test on two of the selected articles to ensure agreement between the researchers. After confirming consistent evaluation results for all items, the quality appraisal was performed for all included articles.[11,28–35] Disagreements were resolved through discussion with a third researcher (HL).

4.6 | Data analysis

Meta-analysis was performed using RStudio version 2023.06.2 on studies that conducted RCTs and measured effects with the same dependent variables. Before testing the overall effect size, heterogeneity among studies was evaluated using the Higgins *I*-squared (I^2) test. The I^2 values were categorized as low, moderate or high based on thresholds of 25%, 50% and 75%, respectively.[54] In this study, literature measuring ICU length of stay showed low heterogeneity, while those measuring muscle strength exhibited moderate to high heterogeneity. Based on this heterogeneity among studies, a random-effects model was used to calculate the effect sizes. The meta-analysis results were presented as weighted mean difference (WMD) or standardized mean difference (SMD) along with 95% confidence intervals (CI).

4.7 | Ethical and research approvals with the date

This is a literature review study and therefore does not require ethical approval. The study protocol was registered with PROSPERO (registration number: CRD42024503944).

5 | RESULTS

5.1 | Study selection

The initial search yielded 943 records. After the elimination of 76 duplicates and the exclusion of 790 studies based on the title and

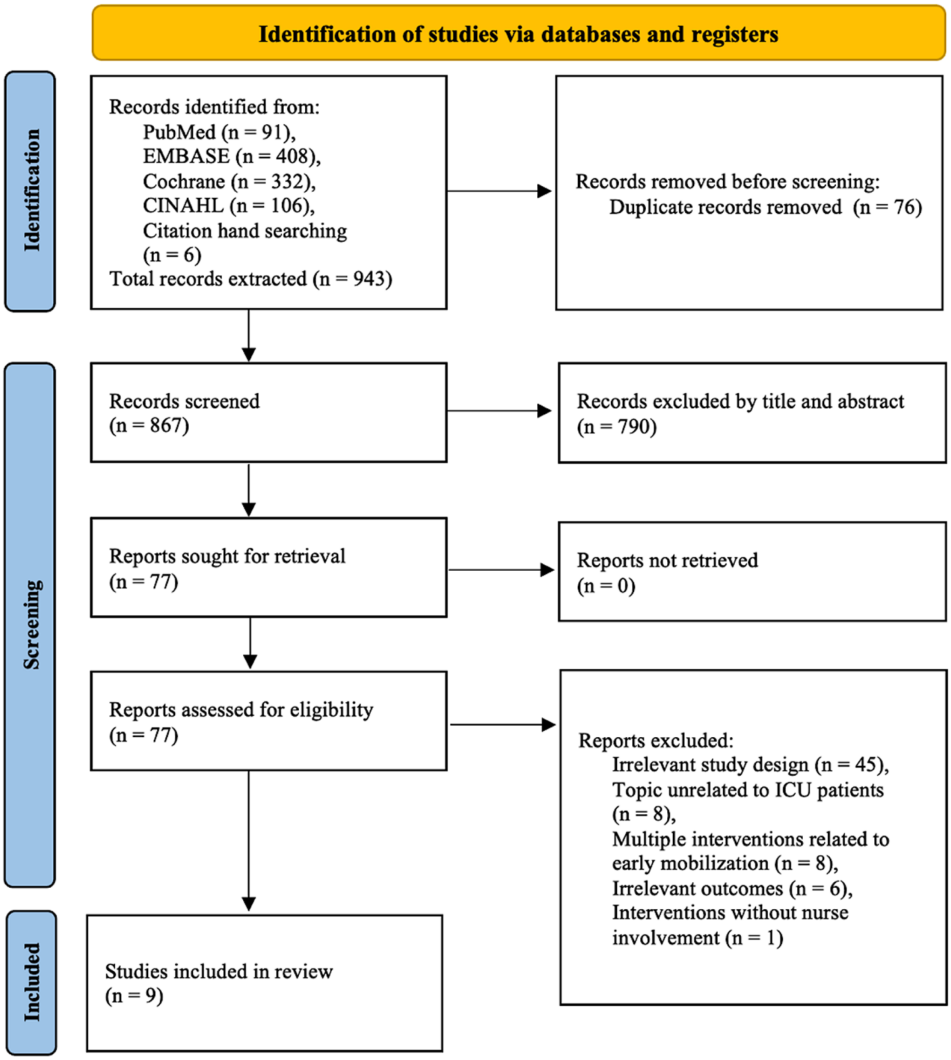


FIGURE 1 Study selection flow diagram (PRISMA 2020).

abstract, 77 studies were included for full-text review. Thereafter, nine studies were selected for the final analysis (Figure 1).

5.2 | Characteristics of the study and participants

The nine studies included in the analysis were published between 2012 and 2022; six were RCTs,[28,29,31–33,35] and three were non-randomized studies (Table 1).[11,30,34]

Three studies were conducted in the United States,[31,34,35] two in Germany[32,33] and one each in Australia,[29] China,[28] Portugal[11] and Turkey.[30] The participant numbers in each study varied between 42 and 300. Although the average age varied, the majority of the participants were in their 50s or 60s. The proportion of male patients was higher in six of the nine studies;[11,28,29,32–34] one study did not specify the male-to-female ratio.[30] The primary diagnoses of the participants were respiratory disease, cardiovascular disease, sepsis and post-surgery conditions. In seven of the nine studies, participants used either mechanical or non-invasive ventilators;[11,28,29,31,33–35] two studies did not provide any details in this regard.[30,32]

5.3 | Risk of bias

Appendix B presents the risk of bias assessment for both RCTs and non-randomized studies. Of the six RCTs, two had a low risk of bias,[32,33] while four raised some concerns because of a lack of blinding and randomization details.[28,29,31,35] However, all six RCTs consistently reported complete analysis results, and outcome measurements were conducted systematically across both the intervention and control groups.[28,29,31–33,35]

Among the three non-randomized studies, two had a moderate risk of bias,[30,34] and one had a high risk.[11] In one study, participant heterogeneity at admission was noted and was likely to affect the muscle strength outcome.[11] Another had a high risk because of significant disparities in missing values among the intervention and control groups.[11] All three studies had a medium risk of outcome measurement bias because of the lack of evaluator blinding.[11,30,34]

5.4 | Early mobilization components

All studies employed a gradual mobilization approach (Table 2). Two studies mentioned starting from the head elevation stage,[11,28] and

TABLE 1 Characteristics of included studies.

First author (publication year)	Country	Study design	Intervention group sample size	Control group sample size	Age (mean ± SD)	Sex (%)	Primary diagnoses (%)	Mechanical ventilation or non-invasive ventilation
Azevedo, P. (2022)	Portugal	Non-randomized study	21	21	Intervention 48.6 ± 13.6 Control 57.2 ± 15.7	Male 60%, female 40%	Pneumonia (12%), polytraumatized (12%), respiratory failure (7%)	Mechanical ventilation
Koyuncu, F. (2022)	Turkey	Non-randomized study	21	21	Intervention 62.81 ± 11.57 Control 63.62 ± 8.99	Not specified	Abdominal surgery (pancreatic, gastrointestinal and colorectal cancer) (100%)	Not specified
Winkelman, C. (2012)	USA	Non-randomized study	55	20	Intervention 65 ± 13.27 Control 66 ± 11.03	Male 51%, female 49%	Respiratory failure or acute lung injury (31%), cardiovascular surgery (21%), gastrointestinal medicine or surgery (21%)	Mechanical ventilation
Winkelman, C. (2018)	USA	RCT	25	29	Intervention 52.68 ± 18.53 Control 59.48 ± 15.56	Male 46%, female 54%	Pulmonary disease (43%), cardiovascular disease (20%)	Mechanical ventilation
Morris, P. E. (2016)	USA	RCT	150	150	Intervention 55 ± 17 Control 58 ± 14	Male 44.7%, female 55.3%	Acute respiratory failure (98.3%), shock (23%)	Mechanical ventilation or Non-invasive ventilation
Nydahl, P. (2020)	Germany	RCT	120	152	Intervention 74 ± 10 Control 70 ± 10.85	Male 55.1%, female 44.9%	Cardiological, endocrinological disease (28%), surgery (43.8%), pulmonary disease (8.5%)	Not specified
Hodgson, C. L. (2016)	Australia	RCT	29	21	Intervention 64 ± 12 Control 53 ± 15	Male 60%, female 40%	Sepsis (66%)	Mechanical ventilation
Schaller, S. J. (2016)	Germany	RCT	104	96	Intervention 66 ± 12.5 Control 64 ± 15.5	Male 63%, female 37%	Visceral surgery (27%), trauma (26%), vascular surgery (17%)	Mechanical ventilation
Dong, Z. H. (2014)	China	RCT	30	30	Intervention 55.3 ± 16.1 Control 55.5 ± 16.2	Male 68%, female 32%	Acute respiratory distress syndrome (32%), abdominal infections (18%), aspiration pneumonia (18%)	Mechanical ventilation

seven studies mentioned using range of motion (ROM) exercises.[11,28,29,31,33–35] Five studies[11,29,32,34,35] included turning (rolling) as a mobilization stage, and dangling (sitting on the edge of the bed) was used as an intervention in all but one of the included studies.[33] Furthermore, the sitting, standing and walking stages were included in all nine studies.

The initiation point of the interventions varied, with two studies starting on the day of enrollment in the study,[31,34] one following at least 48 h of mechanical ventilation[35] and some when the patient's condition had stabilized.[29,30] Four studies did not report the exact time of initiation.[11,28,32,33] The intervention time in each study varied from 15 to 120 min, and the intervention period varied from 1 to >10 days or until discharge from the ICU.

Three studies included staff training that focused on learning how to apply the standardized protocol of early mobilization for patients.[32,34,35] Specifically, ICU staff received group training on the early mobilization protocol, including the template, checklist, safety criteria and mobility scale.[32] Researchers reported that the protocol was consistently applied, as staff received training to ensure its standardized implementation.[34]

TABLE 2 The contents of early mobilization.

	Nurse-led interventions				Multidisciplinary team approach				
Study	**Paulo Azevedo (2022)**	**Koyuncu, F. (2022)**	**Winkelman, C. (2012)**	**Winkelman, C. (2018)**	**Morris, P. E. (2016)**	**Nydahl, P. (2020)**	**Hodgson (2016)**	**Stefan J Schaller (2016)**	**Ze-hua Dong (2014)**
Providers	Rehabilitation nurses	Nurses	Bedside nurses	Trained registered nurses	A physical therapist, an ICU nurse, a nursing assistant	The physiotherapist and/or staff nurses	The physiotherapist, a health assistant, the bedside nurse	Medical doctors, nurses, physical therapists	A physician and a nurse
Name of intervention	Systematized rehabilitation nursing programme	Mobilization protocol	Mobility protocol	Early therapeutic mobility	Standardized rehabilitation therapy	Professional protocol-based mobilization	Early goal-directed mobilization	Early, goal-directed mobilization score algorithm	Rehabilitation therapy
Detailed contents									
Head elevation	✓								✓
Range of motion	✓		✓	✓	✓		✓	✓	✓
Turning (rolling)	✓		✓	✓		✓	✓		
Sitting	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dangling	✓	✓	✓	✓	✓	✓	✓		✓
Standing	✓	✓	✓	✓	✓	✓	✓	✓	✓
Walking	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time of initiation	Not specified	When the vital signs and RASS scores of the patients reached normal values	On the day of enrollment	After 48 h or more on mechanical ventilation	On the day of enrollment	Not specified	After meeting the eligibility criteria	Not specified	Not specified
Duration	10.2 days (mean)	1 day (after completion of surgery on the day of surgery)	2–7 days	4 days (mean)	7 days per week	Not specified	7 days	Not specified	Until discharge from hospital or returning to the pre-admission level of function
Intervention time (intervention dose)	Applied differently at each stage (sitting minimum 20 min–2 h)	Total 4 times (for 15, 25, 35 and 45 min)	20 min of exercise once daily	Twice daily	A total of 3 separate sessions every day	30 min once a day	20 min (median), twice daily	60 min (mean)	Twice daily
Staff training	Not specified	Not specified	+	+	Not specified	+	Not specified	Not specified	Not specified

5.5 | Role of early mobilization providers

In all selected studies, early mobilization of ICU patients was conducted with the involvement of nurses (Table 2). Early mobilization was implemented exclusively by ICU nurses in four of the nine included studies,[11,30,34,35] while the remaining five studies involved collaborative interventions by multidisciplinary teams that included nurses.[28,29,31–33] However, none of the studies provided specific details about the responsibilities or role distribution of nurses within the early mobilization process.

5.6 | Early mobilization–related outcomes

5.6.1 | Outcome measures

Muscle strength was assessed in individual studies using the Medical Research Council Sum Score (MRC-SS) tool, Manual Muscle Test (MMT) scale or portable dynamometer measurements. The MRC-SS scores the strength of each muscle group from 0 to 5 points, with the total score being the sum of the individual scores. The muscle groups primarily assessed in each study were the shoulder abductors, elbow flexors, wrist extensors, hip flexors, knee flexors and foot dorsiflexors. The MMT scale was used to score the muscle strength based on the ICU-acquired weakness protocol. Moreover, a handgrip dynamometer was used to measure grip strength and compare outcomes between the experimental and control groups.

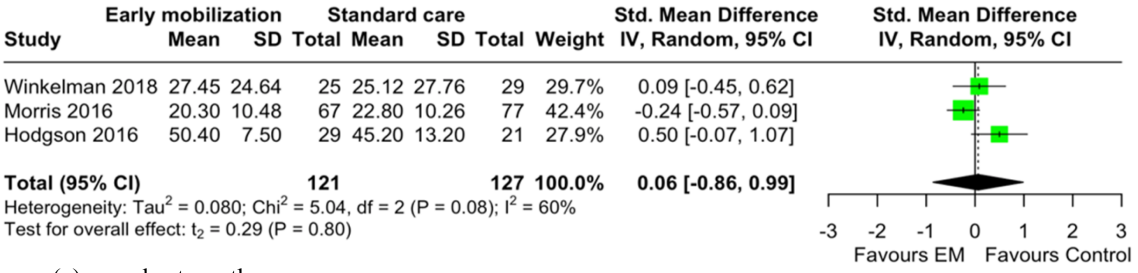
The duration of ICU stay, hospital stay and mechanical ventilation was calculated in days. In one study, mechanical ventilation lasting more than 12 h starting from midnight was considered as 1 day.[35]

The first mobilization time was expressed as the time until the first mobilization after admission or the date on which the patient was first out of bed. The level of mobilization was evaluated either through the ICU Mobility Scale (IMS) level or by categorizing functional capacity into four stages based on the degree of independence.

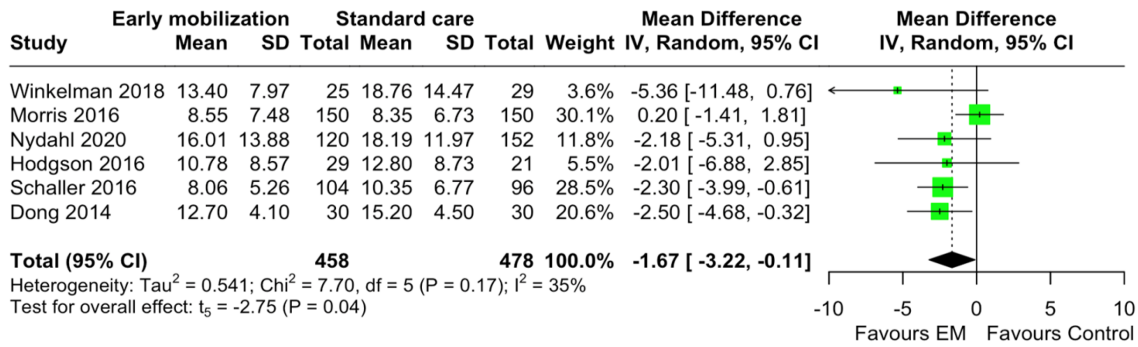
5.6.2 | Primary outcomes

a. Muscle strength

Five studies reported muscle strength outcome data (Appendix C).[11,29,31,34,35] According to the results of each study, the MRC-SS is based on a total scale of 60 points, with scores in the intervention group ranging from 8 to 60, and those in the control group ranging from 26 to 58. For the MMT, the intervention group scored between 31 and 60, whereas the control group scored between 3 and 45. Moreover, results measured using a dynamometer indicated that the intervention group had scores ranging from 7.6 to 84.8, while those of the control group scored between 2.9 and 32. For the meta-analysis, the effect sizes from three RCTs were analysed. According to the pooled estimate, early mobilization did not result in a statistically significant enhancement in muscle strength (WMD = 0.06, 95% CI: −0.86, 0.99; $p = .80$) (Figure 2).



(a) muscle strength



(b) ICU length of stay

FIGURE 2 Forest plot of the effect size: (a) muscle strength and (b) ICU length of stay.

b. Length of ICU stay

Eight studies[28–35] included data on the length of ICU stay. The duration of ICU admission ranged from 1 to 24 days and 1 to 33 days for the intervention and control groups, respectively. Six RCTs reporting ICU length of stay data were included in the meta-analysis. The pooled estimate from the meta-analysis demonstrated that early mobilization was linked to a reduced duration of ICU stay (SMD = −1.67 days, 95% CI: −3.22, −0.11; $p = .04$) (Figure 2).

5.6.3 | Secondary outcomes

The secondary outcomes were the length of hospital stay, mechanical ventilation days and first mobilization time or level of mobilization. The hospital length of stay was measured in three studies,[30,31,33] two of which reported a statistically significant reduction in the intervention group compared with the control group.[30,33] In one study, the intervention group had a median length of stay of 7 days, compared with 12 days in the control group.[30] In another study, the intervention group had a median stay of 15 days, while the control group had a median of 21.5 days.[33] The mechanical ventilation duration was assessed in three studies,[28,34,35] with a significant reduction reported in one study.[28] The mechanical ventilation duration was reported to range from 2.5 to 28 days and 3.5 to 28 days for the intervention and control groups, respectively. Of the six studies[28–30,32–34] that measured the first mobilization time or level of mobilization as an outcome variable, five studies[28–30,33,34] showed that the intervention group had a shorter mobilization onset time or significantly improved levels of mobilization, in contrast to the findings from the control group. Particularly, one study reported that the time to first out-of-bed mobilization was 3.8 ± 1.2 days in the intervention group, compared with 14.9 ± 4.7 days in the control group.[28] Another study found that patients in the intervention group initiated mobilization earlier after ICU admission, with a median time of 6.22 ± 1.95 h, compared with 12.21 ± 3.76 h in the control group.[30]

6 | DISCUSSION

This systematic review evaluated the impact of early mobilization on muscle strength and ICU length of stay and identified the components of early mobilization interventions for ICU patients.

Most participants in the included studies were middle-aged to older adults, with a predominance of male participants. These results are consistent with the mean age and sex ratio of ICU patients reported by Park et al.[36] in their large cohort study. In seven studies, participants used either invasive or non-invasive ventilators. Our analysis suggests that ventilator support, often considered an obstacle to the rehabilitation of critically ill patients,[14,37] may not necessarily impede early mobilization.

Quality appraisals of the studies revealed concerns regarding bias due to deviations from the intended intervention in four of the six RCTs. The nature of the interventions made it challenging to blind study participants and intervention providers to their allocation. However, as objective indicators, such as muscle strength and length of ICU stay were used as outcomes, the blinding of allocation did not critically impact the results. According to Schulz and Grimes, objective results generally have minimal potential for bias, making blinding less important for reducing observer bias than for subjective results.[38] Meanwhile, all three non-randomized studies were assessed to have bias due to confounding, either because of unclear descriptions of confounding factors or because of a lack of corrections. Future studies should control for these confounding variables to improve the validity of the findings.

Four of the nine included studies exclusively involved nurses in early mobilization, while five involved multidisciplinary teams, although the roles of each professional were not specified. Nurses play a crucial role in initiating, co-ordinating and implementing early mobilization, working alongside other health care professionals.[44–46] They closely monitor vital signs and provide input on the feasibility of patient mobility when physicians prescribe rehabilitation. Wang et al.[47] highlighted that fewer than half of early mobilization was performed by multidisciplinary teams, with nurses frequently serving as the main practitioners. Critical care nurses are well-positioned to perform ROM exercises to facilitate patient movement throughout the course of treatment.[48,49] As nurses primarily work at the bedside and maintain constant contact with the patient, they are in a favourable position to provide care tailored to the needs of patients.[51,52]

In practice, when implementing early mobilization for ICU patients, roles are divided among medical professionals rather than multiple staff members performing the same tasks simultaneously, thereby ensuring a more efficient and targeted approach to patient care. Physicians ensure the functionality and secure placement of life-sustaining devices, such as ECMO and ventilators, while nurses manage the maintenance of various patient tubes, closely monitor vital signs for hemodynamic stability and provide explanations to patients and their families about the preparation and process of early mobilization.[22,55,56] Physical therapists apply optimal methods to enhance the patient's physical function, continuously monitoring the patient's capabilities and potential side effects at each stage. However, current early mobilization protocols or guidelines only specify the steps to be applied to the patient, without clearly distinguishing or describing the roles of the medical staff involved in the intervention, leading to ambiguity. Therefore, it is essential to define the allocation of roles among the professionals involved in the early mobilization process, with particular emphasis on exploring the main role of nurses.

Early mobilization generally consisted of progressive exercise interventions, and although differences existed in the timing of each intervention, they were carried out in the same sequence. Although it is recommended to start early mobilization as soon as possible,[10] the timing of initiating early exercise interventions varied across each study. The ideal type, timing and intensity of physical activity and early mobilization have yet to be determined.[53] Determining the appropriate starting point for early mobilization is challenging because of the diverse health conditions of ICU patients. To address this issue,

it is necessary to develop indicators that allow medical staff to make efficient decisions.

Among the analysed studies, three trained intervention providers before implementing early mobilization on patients. A previous study[39] targeted ICU nurses, educating them on the active mobilization of mechanically ventilated patients, which increased their confidence and reduced barriers to early mobilization. Nurses have reported greater awareness of these barriers than other professionals,[36,50] highlighting the need to alleviate obstacles for nurses in early mobilization.

The meta-analysis revealed that early mobilization interventions involving nurses were associated with a notable reduction in ICU length of stay. This finding aligns with those reported by Lai et al.,[42] where ICU hospitalization was shortened in the group of patients on artificial respiration who underwent early mobilization. Additionally, Corcoran et al.[4] reported a 20% lower average ICU length of stay for patients who participated in early mobilization. Similarly, a study by Anna et al. found that longer rehabilitation in ICU patients was linked to shorter ICU stays and improved functional outcomes at discharge.[40]

Among the five studies that measured muscle strength, one revealed a notable enhancement in muscle strength within the experimental group. However, the pooled estimate from the meta-analysis indicated that early mobilization did not result in a statistically significant enhancement of muscle strength. This finding contrasts with the findings presented by Burtin et al.[41] who found that the intervention group showed a higher level of isometric quadriceps strength than the control group. This discrepancy is attributed to variations in the timing of the intervention across studies and the insufficient duration of the intervention, which may have affected changes in muscle strength.

Based on the meta-analysis conducted by Zang et al.,[16] which examined early mobilization in ICU patients, early mobilization was found to substantially alleviate ICU-acquired weakness and shorten ICU length of stay. The difference from this study was that it included early exercise led by a physical therapist without the participation of nurses, and included individual studies that performed electrical muscle stimulation in addition to the progressive exercise stages in the intervention. Additionally, the meta-analysis of early mobilization by Chen et al.[15] found that the overall effect on the length of ICU stay was not statistically significant, differing from this study as it was limited to patients who underwent cardiac surgery.

Furthermore, the findings of the studies indicated that the improvement in mobility in the intervention group compared with the control group.[28–30,33] These findings suggest that early mobilization positively impacts physical recovery by improving patients' mobility.

6.1 | Strength and limitations

The primary strength of this review is rooted in its selection of studies that focused on early mobilization interventions involving nurses as facilitators. By analysing these interventions, we explored the content of the mobilization strategies. The inclusion of studies emphasizing nursing contributions, rather than solely focusing on physical therapy or physician-led interventions, allowed us to provide insights into current issues, specifically highlighting the role of critical care rehabilitation nursing.

Nevertheless, this review has several limitations. This review was limited to studies published in English, potentially introducing a bias. Additionally, as the analysed studies included patients with various medical conditions, generalizing the results would be challenging.

6.2 | Implications and recommendations for practice

Based on these results, developing standardized early mobilization guidelines for ICU patients in the future is necessary. These guidelines should include components, such as the starting point, duration, sequential steps and stopping criteria. Additionally, it is necessary to develop training materials and standardized mobilization programmes that specify the roles of each health care professional caring for ICU patients. In particular, the nurse's role should include close monitoring of patient vital signs, preventing unplanned tube removal and facilitating effective communication and co-ordination among professionals.

7 | CONCLUSION

Our findings reveal that early mobilization was provided to ICU patients using a stepwise approach in all included studies. Nurse-involved early mobilization contributed to improved mobility among ICU patients. Additionally, the meta-analysis confirmed a significant impact of early mobilization in reducing the length of ICU stay. We recommend developing standardized guidelines for future early mobilization practices, clarifying the responsibilities of each professional involved in these interventions. Incorporating these distinctions into the guidelines is essential to ensure efficient implementation and consistent patient outcomes.

AUTHOR CONTRIBUTIONS

All authors have participated in the study and read and approved the submitted version of the manuscript. **Jungmin Lee**: conceptualization, methodology, data extraction, data analysis and interpretation, writing—original draft, review and editing. **Yeonju Kim**: data extraction, data analysis and interpretation, writing—original draft, review and editing. **Hyun Joo Lee**: methodology, data analysis and interpretation, writing—original draft, review and editing, supervision.

ACKNOWLEDGEMENTS

The authors acknowledge Professor Eui Geum Oh (Yonsei University College of Nursing) for providing invaluable instructions regarding the methodology for conducting this systematic review. We also appreciate the assistance of Professor Heejung Kim (Yonsei University College of Nursing) with the process of writing and submitting this review.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in Early-mobilization at https://github.com/pgnht/Early-mobilization/blob/f868744eddd5ce036d45328cca74ac3fe665a4a5/.

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How to cite this article: Lee J, Kim Y, Lee HJ. Nurse-involved early mobilization in the intensive care unit: A systematic review and meta-analysis. *Nurs Crit Care*. 2025;30(2):e13278. doi:10.1111/nicc.13278

APPENDIX A

1. MEDLINE (PubMed) search terms

(intensive care units[MeSH Terms]) OR (intensive care unit*[Title/Abstract]) OR (intensive care*[Title/Abstract]) OR (critical care unit*[Title/Abstract]) OR (critical care*[Title/Abstract]) OR (critically illness*[Title/Abstract]) OR (ICU[Title/Abstract])

(rehabilitation[MeSH Terms]) OR (early ambulation[MeSH Terms]) OR (mobilization[Title/Abstract]) OR (mobilization[Title/Abstract]) OR (rehabilitation[Title/Abstract]) OR (early ambulation[Title/Abstract])

(rehabilitation nursing[MeSH Terms]) OR (nursing intervention[Title/Abstract]) OR (nurse-led[Title/Abstract]) OR (nurse initiate*[Title/Abstract]) OR (nursing program[Title/Abstract]) OR (nursing therapy[Title/Abstract])

#1 AND #2 AND #3.

2. EMBASE search terms

Intensive care unit*: Ab, ti OR intensive care*:Ab, ti OR critical care unit*:Ab, ti OR critical care*:Ab, ti OR critically illness*:Ab, ti OR ICU:Ab, ti OR 'intensive care unit'/exp.

mobilization:Ab, ti OR mobilization:Ab, ti OR rehabilitation:Ab, ti OR early ambulation:Ab, ti OR 'rehabilitation'/exp. OR 'mobilization'/exp.

nursing intervention:Ab, ti OR nurse-led:Ab, ti OR nurse initiate* OR nursing program:Ab, ti OR nursing therapy:Ab, ti OR 'rehabilitation nursing'/exp.

#1 AND #2 AND #3.

3. Cochrane(CENTRAL) search terms

((Intensive care unit* OR intensive care* OR critical care unit* OR critical care* OR critically illness* OR ICU)):Ti, ab, kw.

MeSH descriptor: [Intensive Care Units] explode all trees.

#1 OR #2.

(mobilization OR mobilization OR rehabilitation OR early ambulation):Ti, ab, kw.

MeSH descriptor: [Rehabilitation] explode all trees.

MeSH descriptor: [Early Ambulation] explode all trees.

#4 OR #5 OR #6.

((nursing intervention) OR (nurse-led) OR (nurse initiate*) OR (nursing program) OR (nursing therapy)):Ti, ab, kw.

MeSH descriptor: [Rehabilitation Nursing] explode all trees.

#8 OR #9.

#3 AND #7 AND #10.

4. CINAHL(EBSCOhost) search terms

MH Intensive care units OR TI (Intensive care unit* OR intensive care* OR critical care unit* OR critical care* OR critically illness* or ICU) OR AB (Intensive care unit* OR intensive care* OR critical care unit* OR critical care* OR critically illness* OR ICU).

MH Physical mobility OR TI (mobilization OR mobilization OR rehabilitation OR early ambulation) OR AB (mobilization OR mobilization OR rehabilitation OR early ambulation).

MH Rehabilitation nursing OR TI (nursing intervention OR nurse-led OR nurse initiate* OR nursing program OR nursing therapy) OR AB (nursing intervention OR nurse-led OR nurse initiate* OR nursing program OR nursing therapy).

S1 AND S2 AND S3.

APPENDIX B

See Figures B1–B4.

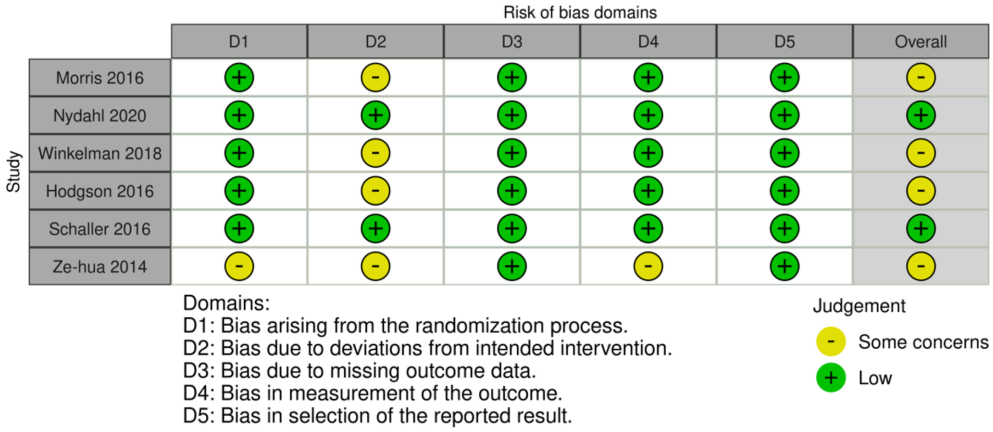

FIGURE B1 Risk of Bias 2.0 plot.

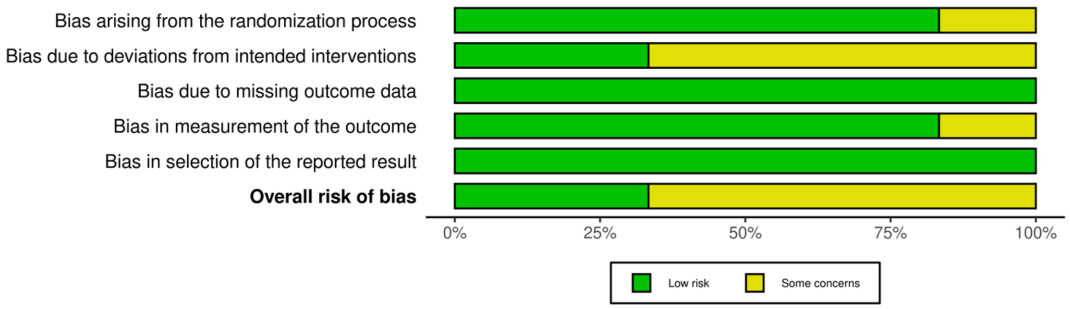

FIGURE B2 Risk of Bias 2.0 summary.

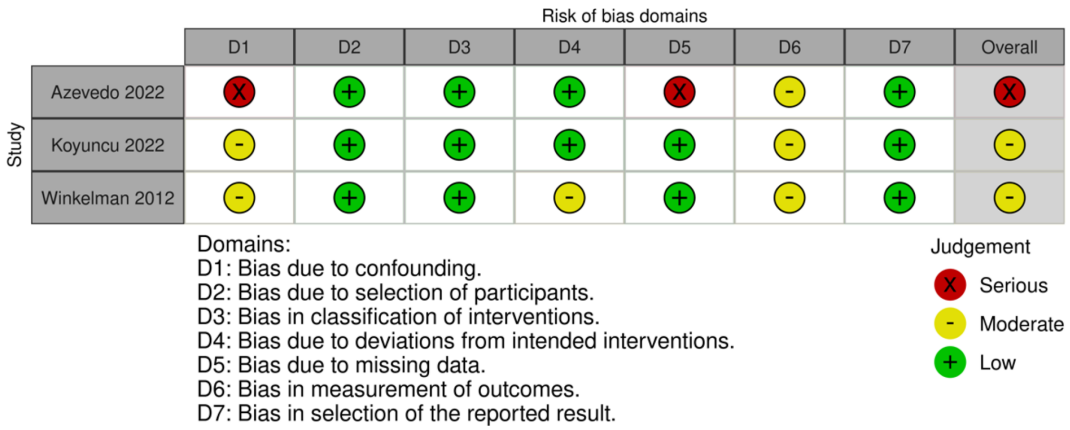

FIGURE B3 ROBINS-I plot.

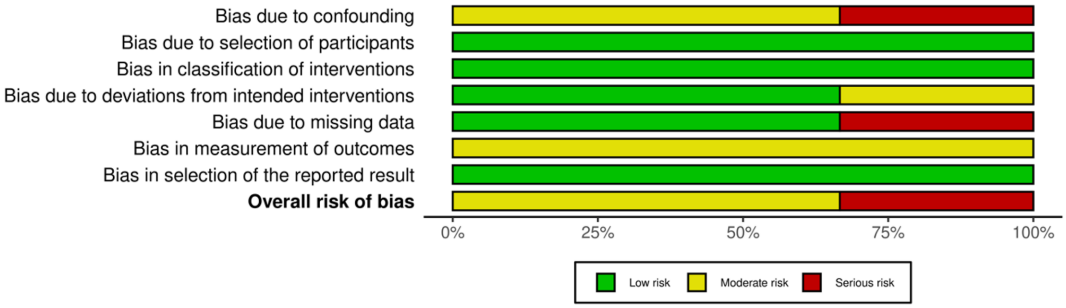

FIGURE B4 ROBINS-I summary.

APPENDIX C

See Table C1.

TABLE C1 The outcomes of nurse-involved early mobilization.

Study	Primary outcomes		Secondary outcomes		
	Muscle strength ($n = 5$)	Length of ICU stay ($n = 8$)	Length of hospital stay ($n = 3$)	Mechanical ventilation days ($n = 3$)	First mobilization time or level of mobilization ($n = 6$)
Azevedo, P. (2022)	+	N/A	N/A	N/A	N/A
Koyuncu, F. (2022)	N/A	+	+	N/A	+
Winkelman, C. (2012)	−	+	N/A	−	+
Winkelman, C. (2018)	−	−	N/A	−	N/A
Morris, P. E. (2016)	−	−	−	N/A	N/A
Nydahl, P. (2020)	N/A	−	N/A	N/A	−
Hodgson, C. L. (2016)	−	−	N/A	N/A	+
Schaller, S. J. (2016)	N/A	+	+	N/A	+
Ze-hua Dong, Z. H. (2014)	N/A	+	N/A	+	+

Note: +, statistically significant difference; −, no statistically significant difference.