



## Early mobilization of trauma patients admitted to intensive care units: A systematic review and meta-analyses



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### ABSTRACT

**Objective:** To determine the effect of early mobilization (EM) in trauma patients admitted to the ICU. Outcomes of interest included mortality, hospital and ICU length of stay (LOS), and duration of mechanical ventilation.

**Methods:** We performed a systematic review of 4 electronic databases (Ovid MEDLINE, Embase, CINAHL, Cochrane Library) and the grey literature. Eligible study designs included randomized control trials, prospective cohorts, or retrospective cohorts. Studies must have compared EM to usual care (i.e., delayed or no mobilization) in trauma patients admitted to ICU. Overall, there were 2982 articles screened and 9 were included in the analysis. Two authors independently performed data extraction using a standardized form. Pertinent study design and population characteristics were recorded, as were prespecified outcome measures. Meta-analyses were performed using random effects models. Study quality was assessed using the Newcastle-Ottawa Scale.

**Results:** Study cohorts ranged from 15 to 1132 patients (median 63) and varied in their inclusion criteria. Most studies utilized a progressive mobility protocol as their intervention. Mortality was reported in 5 studies, of which 3 observed a lower rate with EM; however, meta-analysis showed no difference in mortality between patients mobilized early and those receiving usual care. Eight studies reported on LOS (in-hospital and ICU); although all 8 studies found EM reduced LOS, the difference in LOS was not significant on meta-analysis. Finally, 3 studies reported on ventilator days, all of which observed a reduction in the EM group. On meta-analysis, duration of mechanical ventilation was significantly lower with EM (mean difference −1.18 days, 95% CI, −2.17 – −0.19).

**Conclusions:** Few studies have investigated the effects of EM in trauma ICU patients. The available evidence suggests that patients who receive EM require fewer days of mechanical ventilation, but have similar mortality and LOS compared to those receiving usual care.

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### Introduction

Current management of critically ill patients focuses on rapid resuscitation and reversal of physiologic deterioration with an aim to minimize mortality, length of stay (LOS) in the ICU and hospital, and duration of mechanical ventilation [1]. Traditionally, ICU patient management involves bed rest or immobilization [2]. It is estimated that fewer than 25% of mechanically ventilated patients are mobilized [3]. However, immobility can have negative effects in

multiple organ systems and increase the risk of delirium and ICU-acquired weakness (ICUAW) [4–6].

Development of ICUAW can reduce strength and muscle mass early and rapidly in the critically ill [7,8], and is associated with mortality, prolonged LOS and greater need for mechanical ventilation [9,10]. Practices such as daily waking and minimization of sedation can help to prevent ICUAW [11,12]; however, ICUAW remains a frequent occurrence with its incidence among critically ill patients estimated at 40% [13]. Given the extent and speed with which immobilization causes problems, there has been growing interest in the benefits of early mobilization (EM) in the critically ill including those who remain mechanically ventilated or require ongoing vasopressor support [14–18].

Mobilization in the ICU is defined as physical activity of sufficient intensity to produce physiological benefits including

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enhanced circulation, central and peripheral perfusion, ventilation, muscle metabolism and alertness [19]. Early mobilization in the ICU can involve passive and active rehabilitation modalities including range of motion (ROM), active side-to-side turning, chair sitting, cycle ergometry, exercises in bed, standing, walking, hoist therapy, tilt table, active resistance exercises and neuromuscular electrical stimulation [18,20,21]. Mobilization should be viewed as a medical treatment, taking into consideration the quantity, frequency, duration, and importantly the timeliness of first administration [22]. While mobilization and rehabilitation are often deferred until later in the patient's hospital course, delayed initiation of mobilization may decrease its benefits and result in less than optimal patient outcomes.

In comparison to the general ICU population, trauma patients are typically younger and healthier with fewer comorbidities [23,24]. Considering their pre-injury health status, early initiation of mobilization could help trauma patients avoid unnecessary additional decline and promote quicker return to functional status after recovery from their initial injury. These patients often endure injuries to multiple organ systems and therefore require special consideration as the need to treat an injury to one organ system may confound treatment of another [25]. As well, complex and extensive injuries such as multiple orthopedic injuries can create additional barriers to mobility [26]. Despite these challenges, trauma patients may benefit from a focused mobility program early in the critical phase following injury.

Previous reviews suggest EM in the general ICU population is feasible, safe, and may decrease mortality, LOS and duration of mechanical ventilation [14–17]. The aim of this systematic review was to assess the effect of EM on mortality, LOS and duration of mechanical ventilation in adult trauma patients admitted to the ICU.

## Methods

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [27], and was registered with PROSPERO (CRD42018100819).

### Data sources and search strategy

The search strategy was developed by the authors with assistance from an Evidence Synthesis and Information Services Librarian at the [blinded for review] (Appendix 1). Key words and subject headings pertaining to the research question were adapted in accordance with the syntax for each database. We did not impose any restrictions on publication language or date. The search was executed in the Ovid MEDLINE, EMBASE, CINAHL, and the Cochrane Library databases in June 2018. The database search was complemented by searches of the grey literature, bibliographies of full-text articles, and critical care and trauma conference presentations and poster abstracts. The search was repeated prior to completion of the analysis to identify any articles published after the initial search.

### Article screening

Titles and abstracts from the literature search were imported into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) for initial screening by two authors [blinded for review]. Criteria for inclusion were studies of adult trauma ICU patients which compared the effect of EM with either delayed or no mobilization, and examined at least one outcome measure of interest (mortality, hospital LOS [HLOS], ICU LOS [ILOS], duration of mechanical ventilation). Early mobilization

was defined as any mobilization in the ICU delivered earlier than that received in standard care. We excluded case series or reports, studies including pediatric patients (<18 years of age), and studies where EM was delivered as part of a bundle intervention. Any disagreements between reviewers during the initial screening were resolved by mutual review and discussion. If a study was not limited to trauma patients but met all remaining inclusion criteria, we contacted the authors to request data specifically for the trauma subgroup.

We obtained the full text of all articles deemed relevant based on initial screening. A second stage of screening consisted of full-text review using the same eligibility criteria. We corresponded with multiple study authors in an effort to obtain methodologic clarification, unreported data (e.g., mean and standard deviations if medians were reported), and trauma subgroup data. Inability to provide clarification or data, or failure to respond despite follow-up resulted in study exclusion. Inter-rater agreement for article screening was calculated using unweighted Cohen's kappa. Agreement interpretation was based on established categories: poor ( $\kappa < 0.00$ ), slight (0.00–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–1.00).

### Quality assessment

Two authors (blinded for review) independently assessed study quality using the Newcastle–Ottawa Quality Assessment Scale (NOS) which evaluates studies based on selection of study groups, comparability, and assessment of outcomes [28]. All studies that met eligibility criteria were included in the analysis regardless of NOS score. We compared inter-rater agreement of total NOS scores between reviewers using weighted Cohen's kappa. To further evaluate study quality, we converted the NOS scores to the Agency for Healthcare Research and Quality (AHRQ) standards of “good”, “fair”, and “poor” [29].

### Data extraction and analysis

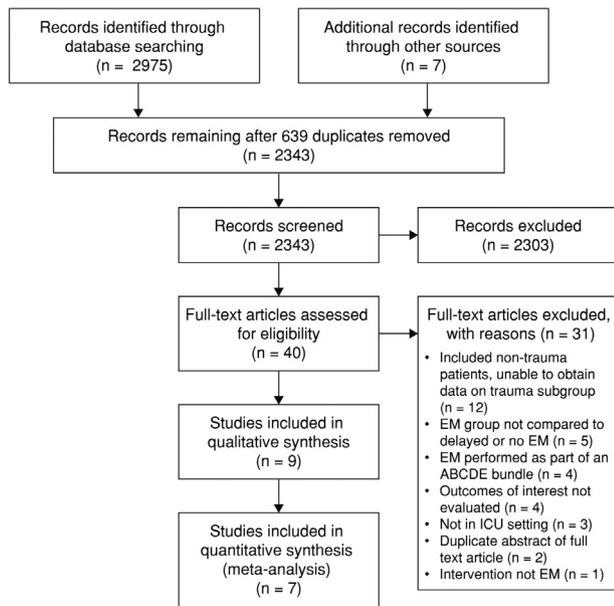
A standardized data extraction form was designed in Microsoft Excel and used to collect the following information: study design, location, institution type and setting, study period, inclusion and exclusion criteria, data sources, description of intervention (EM in ICU) and control (delayed or no mobilization), contraindications to mobilization, sample size, patients' age, sex, ISS, Glasgow Coma Scale (GCS) score, injury type and mechanism, hospital mortality, HLOS, ILOS, duration of mechanical ventilation, and limitations. For included studies, two reviewers (blinded for review) extracted data and carried out checks for accuracy.

Simple descriptive statistics were used to report the results. Meta-analysis of patient outcomes (mortality, HLOS, ILOS, duration of mechanical ventilation) was performed using RevMan Version 5.3 (The Cochrane Collaboration, Oxford, UK). If a study did not report the mean and standard deviation for HLOS, ILOS, or duration of mechanical ventilation, or if this data could not be obtained from the authors, the study was not included in the meta-analyses. Statistical heterogeneity was evaluated with the  $I^2$  statistic. We used Comprehensive Meta-Analysis V3.0 (Biostat, Inc., Englewood, NJ, USA) to assess for publication bias using funnel plots and Egger's test.

## Results

### Study and patient characteristics

The search yielded 2975 records from the 4 electronic databases and 7 records from grey literature and bibliographic searches



**Fig. 1.** Selection of articles for inclusion. EM = early mobilization, ICU = intensive care unit.

(Fig. 1). Following Covidence deduplication of 594 records, manual deduplication of 45 records, and exclusion of 2303 irrelevant articles, 40 articles remained for full text review. A further 31 records were excluded (unweighted  $\kappa$  value, 0.83; almost perfect agreement), leaving 9 articles for analysis.

Characteristics of the 9 included studies are shown in Tables 1 and 2. Most studies were conducted the United States [30–35], with the remaining studies conducted in China [36], Norway [37] and Italy [38]. All were conducted at a single hospital or trauma

center with the exception of 1 study [38]. Research designs included retrospective cohort [31,34,36], prospective cohort [32,37], prospective observational [35,38], bidirectional case-control [30], and 1 study having a retrospective control arm and prospective experimental arm [33]. Study populations included neurotrauma [30,33,37,38], blunt abdominal trauma [34,35], burns [36], and 2 studies with mixed injury types [31,32]. Study cohorts ranged in size from 15 to 1132 patients (median 63) and varied in inclusion criteria. Patients were more likely to be male and under the age of 50. Reporting of injury severity was variable.

The majority of included studies used some form of a stepwise progressive mobility protocol (PMP); this technique introduces passive ROM for unconscious patients and advances them to active ROM exercises as they become more interactive. Two studies used simple ambulation as the mobilization measure [34,35], and Gillick et al. employed upright sitting as their only intervention [30]. Time to commencement of the intervention was variable across studies (Appendix 2). The timing of mobilization initiation was only specified in 2 studies; Wang et al. reported EM beginning within 24 h of admission [35], whereas Gillick et al. indicated an average of 12.7 days between admission and upright sitting [30]. Few studies described the amount, frequency, or duration of mobilization; the PMPs in some studies specified the duration and number of mobility sessions per day, but only 2 studies reported the actual time spent mobilizing [33,37].

## Outcomes

Table 3 shows the outcomes of trauma ICU patients who received EM or usual care. Mortality was reported in 5 studies [31–34,38]. Although 3 of these studies observed a lower proportion of deaths with EM [31,32,38], none found that mortality was significantly different between the two groups. Eight studies assessed HLOS [30–37], and while all 8 observed a decrease in HLOS with EM, this decrease was significant in 4 studies [31,34–36]. One of these studies

**Table 1**  
Characteristics of included studies.

Study (year)	Location	Study Period	Design & Setting	Injury Type	Injury Mechanism	Mobilization in the ICU	
						Usual care	Early mobilization
Gillick (2011) [30]	Illinois, USA	Late 1990's	Bidirectional case-control; Neurotrauma ICU	Neurotrauma	MVC, fall, pedestrian, GSW, assault	Ad hoc PT	Upright sitting mobility program
Andelic (2012) [37]	Norway	2005–2007	PC; Neuro ICU	Neurotrauma	MVC, other	Subacute or no rehab	Early & comprehensive rehab in ICU and continuous chain
Clark (2013) [31]	Alabama, USA	2008–2010	RC; Trauma and Burns ICU	Blunt, penetrating, burn	NR	Bed rest standard activity level, no mobility protocol. PT as needed, average 2–3 days/week	PMP
Taylor (2013) [32]	Michigan, USA	2012	PC; Trauma and Burns ICU	Burn, trauma post-op, trauma non-op, other	NR	NR	PMP
Booth (2016) [33]	Virginia, USA	2010–2013	RC control arm, PC experimental arm; Neurotrauma ICU	Neurotrauma	NR	NR	PMP
Deng (2016) [36]	Chongqing, China	2011–2013	RC; Burn ICU	Burn	NR	Passive ROM	Passive/active ROM, transfer and tilt, ambulation
Bartolo (2017) [38]	Italy	2014	Prospective observational; ICU	Neurotrauma	NR	NR	Sitting on bed/chair, tilt table
Teichman (2018) [34]	Pennsylvania, USA	2008–2014	RC; ICU	Blunt abdominal solid organ injuries	MVC, fall, assault	Bed rest for $\geq 3$ days prior to mobilization	Ambulation once hemoglobin stable
Wang (2017) [35]	California, USA	2014–2016	Prospective observational; ICU	Blunt abdominal solid organ injuries	MVC, assault, pedestrian, motorcycle, fall	Ambulation >24 h	Ambulation <24 h

PC: prospective cohort; RC: retrospective cohort; MVC: motor vehicle collision; GSW: gunshot wound; NR: not reported, PT: physiotherapy; PMP: progressive mobility protocol; ROM: range of motion.

**Table 2**  
Characteristics of trauma patients receiving usual care or early mobilization in the intensive care unit.

Study	Patients	Age		% Male		Injury Severity	
		UC	EM	UC	EM	UC	EM
Gillick 2011	UC: 15 EM: 15	51 ± 17.7	48 ± 20.6	66%	80%	GCS 9–12: 53% GCS ≤8: 47%	GCS 9–12: 53% GCS ≤8: 47%
Andelic 2012	UC: 30 EM: 31	31.2 ± 11.7	27.7 ± 10.9	76%	77%	ISS: 35.1 ± 10.5 GCS: 5.0 ± 1.7	ISS: 36.3 ± 11.5 GCS: 5.3 ± 1.9
Clark 2013	UC: 1044 EM: 1132	44.1 ± 18.5 <sup>a</sup>	46.6 ± 19.6 <sup>a</sup>	75.1% <sup>b</sup>	70.5% <sup>b</sup>	ISS: 23.6 ± 12.8 GCS: 11.9 ± 4.9	ISS: 22.2 ± 12.8 GCS: 11.9 ± 4.9
Taylor 2013	UC: 180 EM: 225	NR	NR	NR	NR	NR	NR
Booth 2016	UC: 184 EM: 159	52.9 ± 21.4	56 ± 23.2	67%	66%	ISS: 20.66 ± 11.36	ISS: 20.99 ± 10.61
Deng 2016	UC: 49 EM: 24	40.76 ± 10.76	38.92 ± 9.35	85.7%	95.8%	NR	NR
Bartolo 2017	UC: 10 EM: 11	47.1 ± 24.8	53.3 ± 24.3	80%	73%	NR	NR
Teichman 2018	UC: 77 EM: 107	47.9	47.3	49%	56%	ISS: 10.1	ISS: 9.9
Wang 2017	UC: 43 EM: 36	31 (IQR 20–54)	32 (IQR 19–44)	72.2%	65.1%	ISS: 19 (IQR 10–25) <sup>c</sup> GCS: 15 (IQR 15–15)	ISS: 13 (IQR 6–17) <sup>c</sup> GCS: 15 (IQR 15–15)

UC: usual care; EM: early mobilization; GCS: Glasgow Coma Scale; NR: not reported; IQR: interquartile range.

Data for age (in years) and injury severity are presented as mean ± standard deviation (if available) and/or median (IQR). Any comparisons reported to be significantly different are indicated with superscript letters.

Note: <sup>a</sup>p < 0.01; <sup>b</sup>p = 0.02; <sup>c</sup>p = 0.005.

**Table 3**  
Outcomes of trauma ICU patients receiving usual care or early mobilization.

Study	Mortality	Hospital LOS		ICU LOS		Ventilation Duration	
		UC	EM	UC	EM	UC	EM
Gillick 2011	NR	26.4	20.5	21.9	16.4	NR	NR
Andelic 2012	NR	120.3 ± 66.2, 123.5 (IQR 109)	91.03 ± 32.0, 88 (IQR 48)	15.0 ± 7.9, 13.5 (IQR 10)	13.48 ± 7.4, 12 (IQR 10)	NR	NR
Clark 2013	UC: 13.2% EM: 11.8%	19.2 ± 28.2 <sup>a</sup>	16.8 ± 18.4 <sup>a</sup>	11.0 ± 16.2	10.4 ± 14.0	8.9 ± 17.4	7.8 ± 13.4
Taylor 2013	UC: 5.56% EM: 4.00%	13.5	10.47	5.76	4.23	NR	NR
Booth 2016	UC: 14.7% EM: 15.1%	13.63 ± 18.3	9.85 ± 9.02	6.52 ± 7.96	5.68 ± 5.73	7.41 ± 9.18	6.50 ± 6.58
Deng 2016	NR	184.4 ± 140.68, 150 (IQR 78–219) <sup>b</sup>	100.75 ± 41.89, 100 (IQR 64.25–119.5) <sup>b</sup>	65.49 ± 38.34, 58 (IQR 40.5–84.5) <sup>c</sup>	39.33 ± 16.11, 38.5 (IQR 29.25–51) <sup>c</sup>	5.53 ± 7.62	2.71 ± 6.73
Bartolo 2017	UC: 20% EM: 0%	NR	NR	17.9 ± 14.8	23.6 ± 12.4	NR	NR
Teichman 2018	UC: 1.3% EM: 1.9%	4.53 <sup>d</sup>	3.46 <sup>d</sup>	1.70	1.75	NR	NR
Wang 2017	NR	5 (IQR 4–7) <sup>e</sup>	2 (IQR 1–3) <sup>e</sup>	3 (IQR 2–3) <sup>f</sup>	0 (IQR 0–2) <sup>f</sup>	NR	NR

UC: usual care; EM: early mobilization; LOS: length of stay; NR: not reported; IQR: interquartile range.

Data for LOS and ventilation duration are presented (in days) as mean ± standard deviation (if available) and/or median (IQR). Any comparisons reported to be significantly different are indicated with superscript letters.

Note: <sup>a</sup>p = 0.02; <sup>b</sup>p = 0.01; <sup>c</sup>p = 0.002; <sup>d</sup>p = 0.005; <sup>e</sup>p < 0.001; <sup>f</sup>p = 0.001.

(Clark et al.) reported their finding of decreased HLOS in the EM group was rendered insignificant after they adjusted for ISS [31]. All 9 studies evaluated the duration of ICU stay. In 7 studies [31–33,35,31–37], ILOS was decreased in the EM group, though only 2 studies reported this difference to be significant [35,37]. The duration of mechanical ventilation was reported in 3 studies, all of which observed a nonsignificant decrease in the number of ventilator days among patients receiving EM [31,33,36].

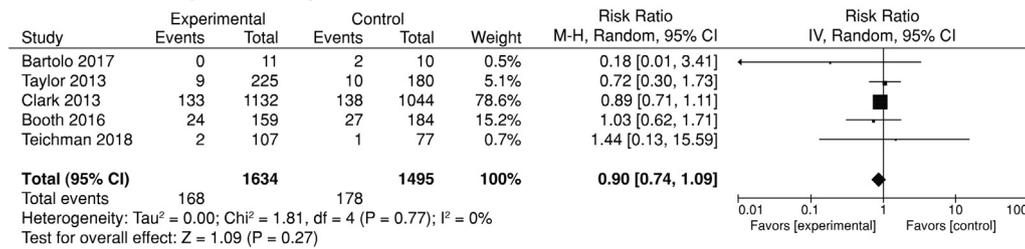
Results of the meta-analyses are shown in Fig. 2. There were 5 studies included in the meta-analysis for mortality [31–34,38]. We did not detect a difference in mortality between EM and usual care groups (0.90, 95% CI 0.74–1.09, I<sup>2</sup> 0%) (Fig. 2A). Meta-analyses for HLOS and ILOS included 4 [31,33,36,37] and 5 [31,33,36,38] studies, respectively. There was no difference in HLOS (mean difference –6.61 days, 95% CI –13.48 – 0.25, I<sup>2</sup> 83%) (Fig. 2B) or ILOS (mean difference –1.68 days, 95% CI –4.44 – 1.08, I<sup>2</sup> 77%) (Fig. 2C) between the EM and usual care groups. Finally, the meta-analysis

for mechanical ventilation included 3 studies [31,33,36]. The duration of mechanical ventilation was lower in trauma ICU patients who received EM, and heterogeneity between studies was low (mean difference –1.18, 95% CI –2.17 – –0.19, I<sup>2</sup> 0%) (Fig. 2D).

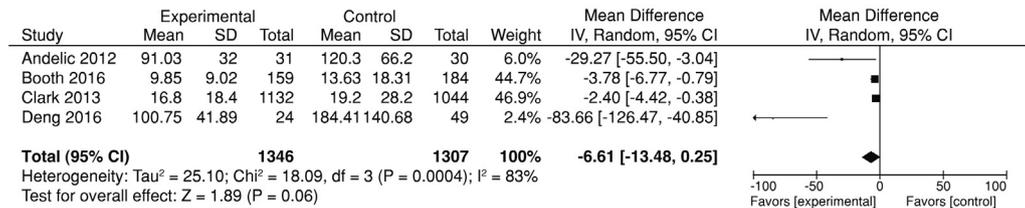
#### Risk of bias

We assessed risk of bias using the NOS for cohort studies (Appendix 3). Inter-rater agreement between the two reviewers was substantial (weighted κ = 0.69). Only 1 study was judged as good quality with low risk of bias across the 3 domains of selection, comparability, and outcome. The remaining studies were categorized as poor quality because of the high risk of bias for comparability of cohorts on the basis of design or analysis. Out of a possible total score of 9, 1 study scored 9 [31], 3 studies scored 7 [30,34,38], 3 studies scored 6 [33,35,36], and 2 studies scored 5 [32,37]. Upon converting NOS scores to AHRQ standards, only 1

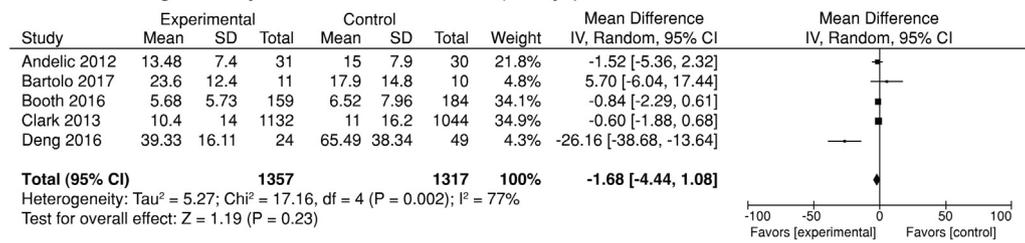
**A. Outcome: in-hospital mortality**



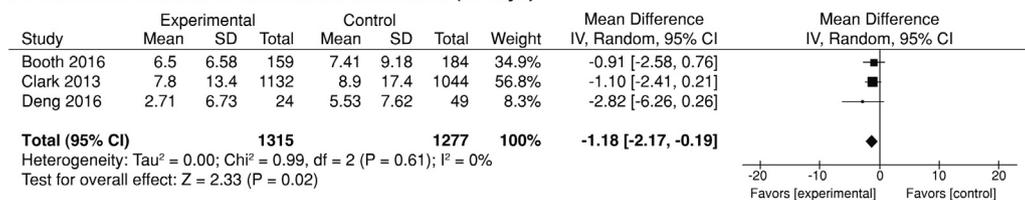
**B. Outcome: length of in-hospital stay (in days)**



**C. Outcome: length of stay in the intensive care unit (in days)**



**D. Outcome: duration of mechanical ventilation (in days)**



**Fig. 2.** Forest plots of risk ratio for mortality and mean difference for hospital length of stay, intensive care unit length of stay, and duration of mechanical ventilation in patients treated with early mobilization compared with controls.

study was deemed to be good quality [31]; the remaining 8 studies were judged to be poor in quality due to a lack of stars awarded in the comparability domain.

Publication bias was evaluated using funnel plots and Egger's test (Appendix 4). Although Egger's test suggests the potential for publication bias among the 4 studies reporting HLOS (intercept -2.54, t = 10.93, p = 0.008), these results are not reliable due to the small number of studies included in the analysis.

**Discussion**

This is the first systematic review to synthesize evidence from the literature on the effects of EM in critically ill trauma patients. An earlier review by Engels et al. investigated the evidence for use of EM to rehabilitate polytrauma patients in the ICU and did not identify any relevant articles [39]. We employed a comprehensive search strategy and corresponded at length with study authors to collect as much data as possible. The results of our meta-analyses suggest that EM is associated with reduced duration of mechanical ventilation in trauma ICU patients, but no difference in mortality or LOS. Further research utilizing more robust study designs is

necessary to generate higher quality data regarding the effect of EM on outcomes in the critically ill trauma population.

This systematic review has several important limitations that must be taken into consideration. Several investigations of mobilization in trauma ICU patients were excluded because EM was performed as part of an ABCDE bundle consisting of Awakening and Breathing coordination, Choice of sedative and analgesic exposure, Delirium monitoring and management, and Early exercise and mobility. Overall, few studies met all inclusion criteria and most of these were lacking in methodologic rigour. The type, intensity, timing, and progression of mobilization varied among included studies; thus, it was difficult to accurately assess the amount of mobilization received by patients. Study authors did acknowledge the challenge in capturing mobilization efforts by all members of the allied health team. One study used physical therapy billable units as a means to quantify the mobilization delivered, but the authors noted that this failed to capture the patients' mobility throughout the day with nursing and respiratory therapy, or on their own [31]. Small sample sizes, lack of blinding of investigators, and variable or inadequate description of the mobilization regimens further limit the generalizability of our

results. In addition, the pre- and post-intervention study design makes it difficult to account for institutional changes or advances in general ICU care between the two assessment periods.

There is growing evidence that EM in the general ICU population improves quality of life, increases ventilator-free days, and decreases hospital and ICU stay [14–17]. Many critical care survivors experience impairment in cognition, psychiatric, and physical function, known as post-intensive care syndrome (PICS) [40]. Patients recovering from PICS may experience decreased quality of life, persistent functional impairment, and perceived muscle weakness years after discharge from hospital [41–43]. Physiologic rationale supports mobilization as an intervention to reduce PICS, including a reduction in oxidative stress and inflammation and improvement in respiratory mechanics [44,45]. Therefore, some centers have instituted EM as part of the ABCDE bundle approach [46,47]. While some studies may endeavor to examine EM independently without any explicit changes to sedation management practices, more frequent sedation interruption is nevertheless required to facilitate participation in the later stages of the mobility protocols. Thus, the components of this bundle are inextricably linked, and it is difficult to ascribe benefit solely to mobilization itself.

For the trauma ICU patient, there are often restrictions to mobilization; patients with cervical spine injuries, elevated intracranial pressure, open abdomen, traumatic aortic injuries, and in situ lumbar drains are examples of cases where certain aspects of mobilization may need to be limited [39]. For this reason, it is essential to have a clear understanding of a patient's injuries, documented limb weight-bearing statuses, and specialized equipment required [33]. Mobilization for trauma ICU patients often requires a team approach since it can be a labor-intensive process. Safety factors to consider include intrinsic factors related to the patient (e.g., hemodynamic stability, cardiovascular and respiratory reserve, and hematological considerations) and factors extrinsic to the patient (e.g., patient attachments, environment, and staffing) [48]. Although mortality, LOS and duration of mechanical ventilation are clearly defined and easily measurable outcomes, the long-term goals of trauma care include the ability of patients to return to their way of life. In addition to survival, return to work, recreation, and the capacity to perform activities of daily living are important measures of trauma center success [49]. Functional measures such as these were not included in the scope of this review due to limited reporting and significant heterogeneity in assessment tools.

## Conclusions

In summary, few studies have investigated the effect of EM on the outcomes of trauma patients admitted to the ICU. The results of the meta-analyses showed a reduction in the duration of mechanical ventilation among patients who received EM, but no difference in mortality or LOS. Larger controlled trials of higher quality are needed to verify the potential benefits of EM on trauma ICU patient outcomes.

The authors listed here (SH, ME, SC, RG) declare they have no conflicts of interest, financial or otherwise, related to this study.

## Declaration of Competing Interest

The authors listed here (SH, ME, SC, RG) declare they have no conflicts of interest, financial or otherwise, related to this study.

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## Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.injury.2019.09.007>.

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