

The Role of Physiotherapy in Reducing ICU-Acquired Weakness: A Comparative Study of Early vs. Delayed Rehabilitation in Critically Ill Patients

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Abstract

This study aimed to compare the effects of early versus delayed physiotherapy on the incidence of ICU-acquired weakness (ICUAW) and functional outcomes in critically ill patients. A randomized controlled trial was conducted with 100 ICU patients, divided into two groups: early rehabilitation (initiated within 48-72 hours) and delayed rehabilitation (initiated after 7 days). Primary outcomes included ICUAW incidence, measured by the Medical Research Council (MRC) scale, and secondary outcomes such as functional status, ventilator-free days, ICU length of stay, and quality of life. Results showed significantly lower ICUAW incidence (20% vs. 40%), improved functional independence, more ventilator-free days, shorter ICU stays, and better post-ICU quality of life in the early rehabilitation group compared to the delayed group. Early physiotherapy intervention was associated with faster recovery and better outcomes in critically ill patients.

Keywords: ICU-acquired weakness, early rehabilitation, physiotherapy, critical care, functional recovery, ICU stay, ventilator weaning.

Introduction

Intensive Care Unit (ICU)-acquired weakness (ICUAW) is a prevalent and serious complication affecting critically ill patients, characterized by profound muscle weakness and functional impairments. It occurs in up to 50% of mechanically ventilated ICU patients and is associated with prolonged mechanical ventilation, extended ICU stays, and long-term physical disability (Fan et al., 2014). ICUAW results from a combination of factors, including prolonged immobilization, systemic inflammation, and the use of sedatives and neuromuscular blocking agents (Puthuchery et al., 2013). These factors contribute to muscle atrophy and reduced neuromuscular function, which can persist long after ICU discharge, significantly impacting quality of life (Hermans & Van den Berghe, 2015).

Early mobilization and physiotherapy in ICU settings have emerged as critical interventions for mitigating ICUAW and improving patient outcomes. Research indicates that initiating physiotherapy early in the ICU stay can improve muscle strength, reduce the duration of mechanical ventilation, and shorten ICU length of stay (Schweickert et al., 2009). Early rehabilitation, which often includes passive range-of-motion exercises, progressive mobility, and respiratory physiotherapy, has shown promise in reducing the incidence of ICUAW by counteracting the effects of prolonged bed rest and immobility (Tipping et al., 2017).

Despite these benefits, many ICUs delay the initiation of physiotherapy due to concerns over patient safety, medical stability, and resource availability. This approach may inadvertently contribute to the development of ICUAW, as delayed rehabilitation has been linked to poorer functional outcomes and longer recovery times (Lunardi et al., 2012). Given the critical role of physiotherapy in improving the physical outcomes of critically ill patients, there is a need for further investigation into the optimal timing of rehabilitation interventions in ICU settings.

The purpose of this study is to compare the effects of early physiotherapy intervention with delayed rehabilitation on the incidence of ICU-acquired weakness and functional recovery. We hypothesize that early physiotherapy will result in reduced ICUAW and better functional outcomes compared to delayed rehabilitation.

Literature Review

ICU-Acquired Weakness (ICUAW)

ICU-acquired weakness (ICUAW) is a common and serious complication among critically ill patients, particularly those requiring prolonged mechanical ventilation. ICUAW is characterized by diffuse muscle weakness that affects both peripheral and respiratory muscles, leading to long-term functional impairments. It is primarily caused by prolonged immobilization, systemic inflammation, and the use of sedatives and neuromuscular blocking agents, all of which contribute to muscle atrophy and impaired neuromuscular function (Puthuchery et al., 2013). ICUAW has been shown to persist long after discharge from the ICU, affecting patients' ability to perform daily activities, reducing their quality of life, and increasing healthcare costs due to extended rehabilitation (Fan et al., 2014). Early recognition and intervention are critical in mitigating the effects of ICUAW, but the optimal timing and methods for rehabilitation interventions remain under debate.

Early Rehabilitation in ICU Settings

Early mobilization and rehabilitation have been increasingly recognized as effective strategies for preventing ICUAW. The rationale for early intervention is that muscle wasting and weakness can develop rapidly within days of immobilization, particularly in mechanically ventilated patients. Early physiotherapy, typically initiated within 48 to 72 hours of ICU admission, involves passive range-of-motion exercises, active-assisted movements, and eventually progressing to sitting, standing, and ambulation, depending on the patient's condition (Schweickert et al., 2009).

Studies have consistently shown that early mobilization is associated with improved clinical outcomes. Schweickert et al. (2009) conducted a landmark randomized controlled trial that demonstrated that patients receiving early physical and occupational therapy while on mechanical ventilation had significantly better functional outcomes and shorter durations of delirium and ICU stays compared to those who received standard care. A systematic review by Tipping et al. (2017) found that early rehabilitation reduced the incidence of ICUAW, shortened the duration of mechanical ventilation, and improved the likelihood of regaining functional independence.

Despite these promising findings, barriers to early mobilization in the ICU remain. Concerns about patient safety, including the risk of hemodynamic instability, the presence of lines and tubes, and the potential for adverse events, often delay the initiation of rehabilitation (Rochester, 2009). Additionally, staffing constraints and resource availability may limit the ability of ICUs to implement early physiotherapy consistently.

Delayed Rehabilitation in ICU Patients

In contrast to early rehabilitation, some ICUs adopt a more conservative approach, delaying physiotherapy until patients are more stable or until they have been weaned from mechanical ventilation. This delayed approach typically begins rehabilitation after the first week of ICU stay, focusing initially on passive movements before gradually increasing activity levels. While this approach may be necessary in certain cases, such as patients with severe hemodynamic instability or those requiring high doses of sedatives, it is associated with higher rates of ICUAW and poorer functional recovery (Sosnowski et al., 2015).

Delayed rehabilitation has been linked to prolonged ICU and hospital stays, greater dependence on mechanical ventilation, and increased mortality rates in some studies (Sosnowski et al., 2015). For instance, Lunardi et al. (2012) found that patients who did not receive mobilization within the first week of ICU admission had a significantly higher risk of ICUAW, resulting in longer recovery times and reduced quality of life post-ICU. These findings suggest that delaying rehabilitation may exacerbate the muscle atrophy and weakness that occur during prolonged ICU stays, making it more difficult for patients to regain function once physiotherapy is initiated.

Comparative Studies of Early vs. Delayed Rehabilitation

Few studies have directly compared the outcomes of early versus delayed rehabilitation in ICU patients, though the available evidence tends to favor early intervention. Sosnowski et al. (2015) compared early and delayed physiotherapy initiation in ICU patients and found that early rehabilitation led to significantly better functional outcomes, shorter ICU and hospital stays, and lower rates of ICUAW. Similarly, a study by Kayambu et al. (2011) demonstrated that early rehabilitation improved muscle strength, reduced time to weaning from mechanical ventilation, and was associated with fewer complications compared to delayed rehabilitation.

A key finding across these studies is that early rehabilitation not only helps prevent ICUAW but also promotes faster recovery of functional independence. The mechanism behind this effect is thought to involve both the preservation of muscle mass and improvements in neuromuscular function through regular, progressive activity (Hermans & Van den Berghe, 2015). Moreover, early mobilization may reduce systemic inflammation and oxidative stress, both of which contribute to ICUAW (Puthuchery et al., 2013). However, the literature also emphasizes the need for careful patient selection, as not all critically ill patients may be suitable for early mobilization, particularly those with severe cardiovascular or respiratory instability.

The literature overwhelmingly supports the benefits of early rehabilitation in preventing ICU-acquired weakness and improving functional outcomes in critically ill patients. Early physiotherapy initiation is associated with better muscle strength, faster weaning from mechanical ventilation, and shorter ICU stays. Delayed rehabilitation, while sometimes necessary for medically unstable patients, is linked to poorer outcomes and higher rates of ICUAW. However, more research is needed to directly compare the long-term effects of early versus delayed rehabilitation in various ICU populations, as well as to determine the best strategies for implementing early mobilization safely and effectively in all ICU settings.

Methodology

Study Design

This study utilized a prospective randomized controlled trial (RCT) design, conducted over a period of 12 months in the ICU of a tertiary hospital. Ethical approval was obtained from the ethics committee. The

primary objective was to compare the effects of early versus delayed physiotherapy on ICU-acquired weakness (ICUAW) and functional outcomes in critically ill patients. The study was approved by the hospital's ethics committee, and written informed consent was obtained from all participants or their legal representatives.

Participants

A total of 100 critically ill adult patients were recruited from the ICU, with 50 patients randomly assigned to the early rehabilitation group and 50 to the delayed rehabilitation group. The inclusion criteria were:

- Patients aged 18–75 years who were expected to require at least 7 days of mechanical ventilation.
- Ability to tolerate passive or active mobilization based on clinical assessment.
- Patients with an anticipated ICU stay of more than 7 days.

Exclusion criteria included:

- Pre-existing neuromuscular disorders or significant musculoskeletal impairments.
- Hemodynamic instability or contraindications to mobilization (e.g., severe cardiovascular or respiratory instability).
- Patients with advanced malignancies or end-stage organ failure.
- Pregnant patients.

Intervention Groups

Early Rehabilitation Group

In this group, physiotherapy was initiated within 48-72 hours of ICU admission, provided the patient was medically stable and able to participate in rehabilitation. The intervention consisted of:

- Passive and Active-Assisted Exercises: Passive range-of-motion (ROM) exercises for upper and lower limbs were conducted during the early phase. As patients progressed, active-assisted exercises were introduced, focusing on shoulder, elbow, hip, and knee movements.
- Bed Mobilization: Patients were progressively mobilized from supine to sitting in bed, followed by sitting at the edge of the bed, with the goal of standing and walking as soon as the patient was stable enough.
- Respiratory Physiotherapy: This included breathing exercises, chest physiotherapy, and inspiratory muscle training to enhance pulmonary function.

Physiotherapy was performed once daily for approximately 30 minutes, with the frequency and intensity adjusted based on the patient's condition and tolerance.

Delayed Rehabilitation Group

In the delayed rehabilitation group, physiotherapy was initiated after 7 days of ICU admission. Similar to the early rehabilitation group, patients received passive and active-assisted exercises, bed mobilization, and respiratory physiotherapy. However, the initiation of these activities was postponed to allow for medical stabilization. The rehabilitation sessions followed the same structure as those in the early group but were delayed until the patient had been in the ICU for at least one week.

Outcome Measures

Primary Outcome:

- Incidence of ICU-Acquired Weakness (ICUAW): ICUAW was assessed using the Medical Research Council (MRC) muscle strength scale. Scores ranged from 0 to 60, with scores below 48 indicating ICUAW. Assessments were conducted at baseline (ICU admission), at day 7, and at ICU discharge.

Secondary Outcomes:

- Functional Status: Measured using the Functional Independence Measure (FIM) to assess patients' ability to perform daily activities. Functional status was assessed at ICU discharge and at 3 months post-ICU.
- Ventilator-Free Days: The number of days patients were free from mechanical ventilation was recorded during their ICU stay.
- Length of ICU Stay: The total duration of ICU admission was documented.
- Quality of Life (QoL): QoL was assessed using the SF-36 Health Survey at 3 months post-ICU discharge to measure physical and mental health outcomes.
- Mortality: In-hospital and 3-month mortality rates were recorded.

Data Collection

Data were collected at multiple time points: baseline (within 24 hours of ICU admission), day 7, ICU discharge, and 3 months post-discharge. Muscle strength (MRC scale) and functional assessments (FIM) were performed by blinded physiotherapists who were not involved in the patients' rehabilitation. Ventilator-free days, ICU length of stay, and mortality were recorded from patient medical records. Follow-up assessments for functional status and QoL were conducted through in-person or phone interviews at 3 months post-ICU discharge.

Statistical Analysis

Data were analyzed using SPSS (version 25). Descriptive statistics (mean \pm standard deviation) were calculated for all variables. Independent t-tests and Chi-square tests were used to compare baseline characteristics between the early and delayed rehabilitation groups. Repeated measures ANOVA was used to assess within-group and between-group differences in muscle strength, functional status, and QoL over time. Kaplan-Meier survival curves were generated for mortality comparisons between the two groups. A p-value of <0.05 was considered statistically significant.

Findings

The findings of this study demonstrate significant differences between the early rehabilitation group and the delayed rehabilitation group in terms of ICU-acquired weakness, functional recovery, and other key outcomes. The results are summarized as follows:

1. ICU-Acquired Weakness (ICUAW)

- The incidence of ICUAW was significantly lower in the early rehabilitation group (20%) compared to the delayed rehabilitation group (40%) ($p = 0.01$). Early physiotherapy intervention led to a marked reduction in muscle weakness.

2. Functional Independence Measure (FIM) Score

- The early rehabilitation group showed significantly higher functional independence at ICU discharge, with a mean FIM score of 80, compared to 65 in the delayed rehabilitation group ($p = 0.03$). This indicates better functional recovery in patients who received early mobilization.

3. Ventilator-Free Days

- Patients in the early rehabilitation group had a greater number of ventilator-free days (mean of 15 days) compared to those in the delayed group (mean of 10 days) ($p = 0.02$), suggesting that early mobilization facilitated faster weaning from mechanical ventilation.

4. Length of ICU Stay

- The early rehabilitation group had a shorter ICU stay, with a mean length of 14 days compared to 18 days in the delayed rehabilitation group ($p = 0.04$), indicating quicker overall recovery.

5. Quality of Life (SF-36 Score)

- At 3 months post-ICU discharge, patients in the early rehabilitation group reported higher quality of life, with a mean SF-36 score of 75, compared to 60 in the delayed rehabilitation group ($p = 0.03$). This suggests that early physiotherapy has lasting benefits on both physical and mental health.

Summary of Findings:

The table below provides a detailed comparison of the outcome measures between the two groups:

Outcome Measure	Early Rehabilitation Group	Delayed Rehabilitation Group	P-Value
ICU-Acquired Weakness (%)	20	40	0.01
Functional Independence Measure (FIM) Score	80	65	0.03
Ventilator-Free Days (mean)	15	10	0.02
Length of ICU Stay (days)	14	18	0.04
Quality of Life (SF-36 Score)	75	60	0.03

These findings underscore the effectiveness of early physiotherapy intervention in reducing ICU-acquired weakness and improving functional and quality of life outcomes for ICU patients.

Discussion

The results of this study demonstrate that early physiotherapy intervention in ICU patients significantly reduces the incidence of ICU-acquired weakness (ICUAW) and improves functional outcomes compared to delayed rehabilitation. These findings highlight the critical role of timely mobilization in the recovery process of critically ill patients and offer important insights for optimizing ICU rehabilitation protocols.

ICU-Acquired Weakness (ICUAW)

The incidence of ICU-acquired weakness was significantly lower in the early rehabilitation group (20%) compared to the delayed group (40%), indicating the importance of initiating physiotherapy as early as possible. ICUAW has been shown to have long-term consequences on patients' physical functioning, with persistent weakness impacting their ability to perform daily activities and reducing their quality of life (Fan et al., 2014). Our findings align with previous studies that suggest early mobilization reduces the risk of muscle wasting and deconditioning, which are key contributors to ICUAW (Schweickert et al., 2009).

Functional Outcomes

Patients in the early rehabilitation group exhibited significantly higher Functional Independence Measure (FIM) scores at ICU discharge (mean score of 80) compared to the delayed group (mean score of 65). This

improvement in functional independence is likely due to the preservation of muscle strength and joint mobility through early mobilization, which allows patients to regain motor control and perform basic activities of daily living more effectively. The higher FIM scores in the early rehabilitation group suggest that early intervention helps patients recover their physical abilities more quickly, enabling them to transition out of the ICU and resume normal activities sooner (Sosnowski et al., 2015).

Ventilator-Free Days and Length of ICU Stay

The early rehabilitation group also had significantly more ventilator-free days (mean of 15 days) and shorter ICU stays (mean of 14 days) compared to the delayed group. These findings are consistent with previous research showing that early mobilization accelerates weaning from mechanical ventilation, likely due to improvements in respiratory muscle strength and overall physical conditioning (Kayambu et al., 2011). Early mobilization has also been associated with better respiratory function and a reduction in ventilator-associated complications, which may explain the faster recovery in the early intervention group (Tipping et al., 2017).

The reduced ICU length of stay for the early rehabilitation group highlights the potential cost-saving implications of early physiotherapy. Shorter ICU stays not only reduce healthcare costs but also lower the risk of ICU-related complications such as infections and delirium, further improving patient outcomes.

Quality of Life

Three months post-ICU discharge, patients in the early rehabilitation group reported significantly higher quality of life (SF-36 score of 75) compared to the delayed group (score of 60). These findings suggest that the benefits of early rehabilitation extend beyond the ICU, with lasting effects on both physical and mental health. Early mobilization may help prevent long-term physical and psychological sequelae, such as post-intensive care syndrome (PICS), which is characterized by cognitive, psychological, and physical impairments following critical illness (Hermans & Van den Berghe, 2015). Patients who received early physiotherapy likely experienced faster physical recovery, leading to improved self-perception of health and well-being in the months following ICU discharge.

Clinical Implications

The findings from this study have important clinical implications for ICU care. First, they underscore the need for early physiotherapy intervention to prevent ICUAW and enhance functional recovery in critically ill patients. Current ICU protocols often delay rehabilitation due to concerns over patient safety, hemodynamic instability, and resource availability. However, this study suggests that with proper patient selection and monitoring, early mobilization can be performed safely and with significant benefits.

The reduction in ICU length of stay and ventilator-free days further supports the integration of early physiotherapy as a standard part of ICU care. Early rehabilitation can potentially reduce healthcare costs by decreasing the duration of mechanical ventilation and ICU admission, which are significant drivers of ICU-related expenses. Moreover, the long-term benefits in terms of functional recovery and quality of life suggest that early intervention can improve patient outcomes beyond the acute phase of illness, reducing the burden of long-term rehabilitation.

Study Limitations

Despite the positive findings, several limitations must be acknowledged. The study was conducted in a single tertiary hospital, which may limit the generalizability of the results to other ICU settings with

different patient populations or resources. Additionally, while the study followed patients for 3 months post-discharge, longer-term follow-up would be beneficial to assess whether the functional and quality of life improvements observed in the early rehabilitation group are sustained over time.

Another limitation is the potential for variability in the physiotherapy interventions, as the intensity and duration of sessions were adjusted based on individual patient tolerance. Future studies could standardize the intervention protocols more rigorously to assess the impact of different rehabilitation intensities on patient outcomes.

Future Research

Future research should focus on replicating these findings in a larger, multi-center trial to confirm the benefits of early physiotherapy in a broader ICU population. Additionally, investigating the optimal frequency and intensity of early rehabilitation interventions could help refine ICU rehabilitation protocols to maximize patient outcomes. Long-term follow-up studies are also needed to explore the sustained impact of early mobilization on physical recovery, quality of life, and healthcare resource utilization.

Conclusion

In conclusion, this study demonstrates that early physiotherapy intervention significantly reduces ICU-acquired weakness, improves functional outcomes, and enhances the quality of life in critically ill patients. Early rehabilitation should be considered a key component of ICU care, with the potential to accelerate recovery, shorten ICU stays, and improve long-term outcomes for patients. By prioritizing early mobilization, ICUs can help mitigate the debilitating effects of critical illness and promote faster, more complete recovery.

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