

## LITERATURE REVIEW

## The Transition from Delayed Physiotherapy to Early Physiotherapy in Intensive Care Patients: A Bibliometric Analysis

Atika Rahmah<sup>1</sup>, Arsie Noor Rafidah<sup>2</sup>, Yazid Azhari Utama<sup>3</sup>, Yuanita Citra Syafitri<sup>1</sup>, Farkhana Dwi Ariyani<sup>4</sup>, Wikha Aprian<sup>5</sup>

<sup>1</sup> Faculty of Medicine, Sebelas Maret University, Indonesia

<sup>2</sup> Surakarta Central General Hospital, Indonesia

<sup>3</sup> Faculty of Medicine and Health Science, Muhammadiyah University of Yogyakarta, Indonesia

<sup>4</sup> Buah Hati General Hospital Ciputat South Tangerang, Indonesia

<sup>5</sup> General Hospital Tamiang Layang, Barito Timur, Indonesia

### ABSTRACT

**Introduction:** Critically ill patients in the Intensive Care Unit (ICU) require timely and comprehensive interventions to ensure safety and optimize recovery. Early physiotherapy serves as a vital component of critical care, contributing to patients' physical, psychological, and long-term functional recovery.

**Methods:** The study employed a bibliometric and systematic literature review to analyze research trends in early physiotherapy. Relevant articles were retrieved from SCOPUS-indexed journals, screened based on relevance, keywords, and abstracts, and analyzed using Mendeley for reference management and VOSviewer for bibliometric visualization.

**Results:** The analysis delineated six thematic clusters: (1) pathological classification and therapeutic modalities, (2) patient compliance, (3) therapeutic approaches, (4) physiotherapy in critical care settings, (5) condition-specific therapeutic methods, and (6) safety procedures. These clusters encapsulate the predominant research trajectories and focal domain within the corpus of early physiotherapy literature.

**Conclusion:** Early physiotherapy in critical care substantially enhances patients' psychological well-being, physical functioning, and overall quality of life, while mitigating complications and reducing hospitalization costs. The findings highlight the importance of integrating early physiotherapy as an integral component of standardize ICU patient management.

**Keywords:** *Patient, disease critical care, intensive care unit, early physiotherapy, bibliometric analysis*

Correspondence Detail:

**Atikah Rahmah**

Faculty of Medicine, Universitas Sebelas Maret, Indonesia

Email: [atikarahmah.dr@gmail.com](mailto:atikarahmah.dr@gmail.com)

## INTRODUCTION

The Intensive Care Unit (ICU) is a specialized hospital department that provides advanced, continuous care for critically ill patients with life-threatening conditions requiring constant monitoring, multidisciplinary management, and prompt intervention. These patients often present with severe illness or trauma that necessitates intensive, prolonged treatment. Consequently, ICU hospitalization frequently leads to prolonged immobilization, resulting in physical, psychological, and functional impairments. Bed rest lasting three weeks or more can cause marked muscle weakness and atrophy, with a 3–11% reduction in muscle mass.<sup>1</sup> Furthermore, immobility heightens the risk of complications such as ICU-acquired weakness, pneumonia, deep vein thrombosis, pulmonary embolism, pressure ulcers, and cardiovascular deconditioning.<sup>2–4</sup>

Recognizing these risks, modern hospitals have increasingly integrated physiotherapy as a vital component of ICU patient management.<sup>2,5</sup> Physiotherapy aim to preserve or restore physical function, enhance mobility, and support respiratory and musculoskeletal recovery once patients achieve medical stability. Evidence suggests that absent or delayed physiotherapy may lead to long-term complications such as neuromuscular weakness, cognitive dysfunction, and difficulty in weaning patients from mechanical ventilation.<sup>6–8</sup> Prolonged ventilator dependence further elevates the risk of respiratory infections, including ventilator-associated pneumonia.<sup>9,10</sup> Therefore, implementing early physiotherapy is critical for improving patient outcomes and accelerating recovery.

Early physiotherapy has demonstrated substantial benefits for critically ill patients by improving pulmonary function, increasing muscle strength, and enhancing psychological stability.<sup>11,12</sup> It also mitigates the risk of secondary complications, shortens ICU and hospital stays, and improves long-term quality of life.<sup>13,14</sup> Physiotherapists play an integral role in addressing the consequences of immobilization, restoring normal breathing patterns, and promoting overall functional recovery through

individualized and progressive rehabilitation programs.<sup>15</sup>

In addition, early physiotherapy has been effectively implemented in patients with diverse critical conditions, such as pneumonia, coronary artery disease, malignancy, and post-COVID-19 respiratory complications.<sup>16–19</sup> Interventions such as active sitting, walking, and light exercise facilitate neuromuscular restoration, minimize pulmonary complications, and accelerate rehabilitation. Importantly, these interventions should be initiated as soon as the patient is clinically stable and be continued throughout ICU care and post-discharge recovery.<sup>20</sup>

Accordingly, to ensure safe and effective practice, physiotherapists must adhere to strict infection control protocols, including disinfectants use, personal protective equipment, or ultraviolet sterilization to prevent cross-contamination.<sup>21</sup> These precautions are particularly critical in high-risk settings such as the ICU, where exposure to pathogenic microorganisms is prevalent.

Given growing evidence of its efficacy, early physiotherapy requires systematic examination to identify research trends and gaps. The study presents a bibliometric analysis of research on early physiotherapy among critically ill ICU patients, aiming to deepen theoretical understanding and guide evidence-based physiotherapy practices to improve patient outcomes.

## METHOD

The study employed a systematic literature review with a bibliometric approach to explore research trends and thematic patterns in early physiotherapy for critically ill patients in the Intensive Care Unit (ICU). The review follows three primary stages: exploration, evaluation, and transcription of findings aligned with the study's objectives.<sup>22,23</sup>

### Search Strategy

The literature search was conducted using the SCOPUS database, selected for its extensive

coverage of peer-reviewed journals in the health sciences. Keywords combinations such as “early physiotherapy”, “rehabilitation”, and “critical care” were applied. Nonetheless, the search was restricted to English-language articles published between 2000 and 2025 to ensure the inclusion of recent and relevant evidence reflecting current physiotherapy practices.

## Inclusion and Exclusion Criteria

- a. The inclusion criteria were:
  - 1) Peer-reviewed articles published between 2000–2025.
  - 2) Studies discussing the implementation, effects, or benefits of early physiotherapy in critically ill or ICU patients.
  - 3) Articles available in full-text and indexed in SCOPUS.
- b. The exclusion criteria were:
  - 1) Non-English publications.
  - 2) Conference abstracts, editorials, or book reviews.
  - 3) Studies not directly related to physiotherapy in critical care contexts.

## Screening and Data Extraction

The initial search identified 325 SCOPUS-

indexed articles related to physiotherapy in critical care. Titles and abstracts were screened using Mendeley software to exclude irrelevant studies. Subsequently, full-text screening was performed to ensure all included articles met the eligibility criteria. Duplicates and studies without sufficient methodological detail were also excluded at this stage.

## Data Analysis

The final dataset was analyzed using VOS viewer for bibliometric mapping and visualizing research trends related to early physiotherapy in critically ill patients. The analysis focused on keyword co-occurrence networks, employing author keywords set as the unit of analysis with full counting applied. A minimum threshold of five keywords occurrences was set to ensure the most relevant and frequently discussed topics. The association strength normalization method was used to cluster related terms into thematic groups. The mapping enabled the identification of major research domains, emerging themes, and interconnections among studies. Additionally, articles were further categorized by relevance, thematic substance, and citation frequency to strengthen the interpretive accuracy of the clusters. The complete analytical workflow, including literature search, selection criteria, and analytical procedures, is illustrated in Figure 1. The systematic process ensured a comprehensive, transparent, and replicable analysis of the existing literature on early physiotherapy for critically ill ICU patients.



**Figure 1. Stage scheme study**

The scheme in Figure 1 outlines the workflow, which includes defining objectives, conducting literature research, selecting and reviewing relevant articles, summarizing data, and analyzing the results. Each article was systematically reviewed to identify research objectives and strengthen the study’s conceptual foundation. The bibliometric analysis using VOS viewer facilitated

data visualization and pattern recognition.<sup>24</sup> VOS viewer generated visual maps of frequently occurring keywords, providing insights into the main themes of early physiotherapy research for critically ill patients.<sup>25</sup> The visualizations illustrate how key concepts interrelate and contribute to understanding the benefits of implementing early physiotherapy in ICU settings.<sup>26</sup>

## RESULTS

The bibliometric analysis was conducted using the VOS viewers. VOS viewers can generate three types of visualization that explain research development, publication volume, and bibliographic connection among studies. The results of VOS viewers analysis are as follows:

### Overlay visualization

Overlay visualization provides an effective means of illustrating research development over time.<sup>27</sup> The results of the overlay visualization analysis are as follows: Figure 2 shows that the study on the initiation physiotherapy became more prominent in 2019. During this year, numerous studies explore muscle mass and thickness, quadriceps, quadriceps femoris, and vastus lateralis muscles, exercise therapy, immobilization, bicycle ergometry, cycling, psychology, anxiety disorder, lousy rest, early mobilization, physical activity, respiratory track parameters, intensive care unit mobility, sleep disorders, ultrasonography, passive movement, range of motion, pathophysiology, patient discharge, and hand strength.

In 2020, research topics expanded to physical therapy modalities, critical care, critically ill patients, rehabilitation care, critical trials, traumatic brain injury, cognitive defects, prospective studies, multicenter studies, depression, mortality, pneumonia, exercise, body position, and rehabilitation care. Studies in 2021 further explored physiotherapy practices in relation to patient age, length of stay, early mobilization and ambulation, patient mobility, rehabilitation outcomes, and risk factors. Additional themes included occupational therapy, complications, respiratory training, delirium, hypertension, benzodiazepine use, and anxiety among ICU patients.

In 2022, research began to emphasize sepsis management, burn rehabilitation, range of motion exercises, activities of daily living, blood pressure control, mortality rates, body weight monitoring, and recovery from COVID-19. Additional topics included healthcare facility practices, physical

function, electrotherapy, medical history, sedative use (midazolam), respiratory muscle training, and overall muscle strengthening. In 2023, research interests further diversified, covering renal replacement therapy, fraction of inspired oxygen, diabetes mellitus, exercise interventions, antibiotic efficacy and safety, albumin levels, headache management, agitation and sedation assessment (Richmond scale), auscultation techniques, bleeding risks, predictor variables, organ failure scoring, body mass and motor performance, blunt trauma, spinal cord injuries, decompression surgery, abdominal pain, coronary care, elevated blood pressure, in-bed exercise, neurosurgical procedures, self-care, and sleep hygiene.

Based on the analysis presented in Figure 2, research on physiotherapy in critical care began to emerge around 2019 and gained increasing attention from 2021 onward. The findings indicate that early physiotherapy remains a relatively recent and evolving research domain that warrants further investigation.<sup>28,29</sup>

### Density visualization

Density visualization depicts the extent to which specific clusters have been researched by researchers.<sup>30</sup> The result of the analysis is shown in Figure 3: Figure 3 presents the development of physiotherapy study. The color gradient, ranging from yellow to red, indicates the intensity of research activity where warmer colors represent areas with higher publication density. The analysis reveals that topics such as physiotherapy and heart failure exhibit strong research concentration, shown in yellow. In contrast, other areas appear in green, suggesting comparatively limited exploration. Overall, the findings indicate that studies specifically addressing early, and delayed physiotherapy remain underrepresented in the current literature.

### Network visualization

Network visualization shows a bibliographic connection between items in each cluster.<sup>31</sup> The network visualization analysis research as follows: Figure 4 illustrates the

connection between bibliometrics and items in physiotherapy. The analysis identified 11 clusters comprising a total of 323 items. The clusters are categorized as follows:

- a. **Cluster 1**, represented in red, comprises 68 items primarily related to acute kidney failure, albumin blood level, antibiotic agent, anxiety, arterial gas, aspiration, assisted ventilation, auscultation, benzodiazepine, blood gas analysis, blood pressure, blood transfusion, body temperature, brain edema, breathing rate, burn, burn patient, burns, case report, chronic kidney failure, chronic obstructive lung, corticosteroid, creatine kinase, creatinine, depression, diabetes mellitus, disease severity, drug efficacy, drug safety, drug substitution, drug withdrawal, early diagnosis, electroencephalogram, fraction of inspired oxygen, headache, health care facility, heart rate, hydroxychloroquine, hypotension, immobility, immune response, immunosuppressive agent, lactate blood level, long term care, lorazepam, mean arterial pressure, medical history, mental disease, mortality, mortality rate, olanzapine, oxygen saturation, patient transport, practice guideline, procalcitonin, psychology, renal replacement therapy, resuscitation, Richmond agitation sedation, risk factors, sepsis, septic shock, sequential organ failure assessment score, sleep disorder, thorax radiography, training, valproic acid, vasoactive agents.
- b. **Cluster 2**, represented in green, comprises 50 items from acute respiratory distress syndrome, acute respiratory failure, adult respiratory distress syndrome, breathing exercise, community acquired infection, comorbidity, continuous positive airway pressure, coronavirus, coronavirus disease 2019, coughing, disease assessment, disease exacerbation, early mobilization, early rehabilitation, emergency care, endurance training, fatigue, grip strength, high flow nasal cannula therapy, hyperinflation, hypertension, ICU, intensive care unit, lung auscultation, lung clearance, lung gas exchange, multiple trauma, muscle atrophy, muscle training, oxygen desaturation, oxygen therapy, pain intensity, patient positioning, physical therapy, pleural effusion, pneumonia, viral pneumonia, positive end expiratory pressure ventilation, pulmonary rehabilitation, respiratory control, respiratory distress, respiratory failure, six minute walk test, spirometry, surgical intensive care unit, tachycardia, tertiary health care, tracheotomy, treatment duration, and viral pneumonia.
- c. **Cluster 3**, represented in blue, comprises 49 items, which are assessment of humans, bicycle ergometry, body weight, clinical protocol, critical ill, critically ill patients, critically ill patients, daily life activity, diet therapy, early ambulation, early in bed cycling, echography, electric stimulation therapy, electrostimulation, electrotherapy, enteric feeding, exercise therapy, hand strength, heart failure, ICU mobility scale, immobilization, intensive care unit mobility, kinesiotherapy, muscle mass, muscle strength, muscle thickness, muscle weakness, nervous system diseases, neuromuscular electrical stimulation, passive movement, pathophysiology, physical function, physical performance, physiology, quadriceps femoris muscle, quadriceps muscle, randomized controlled trials as topic, recovery of function, rehabilitation care, scoring system, sensitivity analysis, stroke, stroke rehabilitation, systematic review, treatment outcome, ultrasonography, upper limb, vastus lateralis muscle.
- d. **Cluster 4**, represented in yellow, comprises 37 items, centered on anxiety disorder, cardiovascular disease, cognitive defect,

- coma, correlation analysis, critical care, delirium, double-blind procedure, early mobility, electronic medical record, family relations, health personnel attitude, home care, hospital discharge, injury, intensive care, intensive care units, length of stay, long-term outcomes, male, multicenter study, neurologic disease, patient care bundles, patient discharge, patient safety, pediatric intensive care unit, physician, placebo, post-intensive care syndrome, posttraumatic stress disorder, prevalence, prospective studies, respiratory track disease, sleep hygiene, sleep quality, tertiary care center, traumatic brain injury.
- e. Cluster 5, represented in purple, comprises 36 items primarily on adult, aerobic exercise, bacterial pneumonia, bed rest, bleeding, breathing muscle, cardiac surgical procedure, clonidine, coronary artery bypass graft, coronary artery disease, coronary care unit, dexmedetomidine, disease course, dobutamine, dyspnea, exercise tolerance, extubation, fever, heart rehabilitation, heart surgery, inotropic agent, lactic acid, midazolam, middle-aged, nonsteroidal anti-inflammatory agent, outpatient care, physical activity, postoperative complications, postoperative complications, postoperative period, respiratory tract parameters, soothing agent, systolic blood pressure, tramadol, treatment failure, valvular heart disease.
  - f. Cluster 6, represented in light blue, comprises 24 item of birth injury, body position, clinical examination, conservative treatment, coping behavior, Delphi study, early intervention, female, newborn infant, premature infant, motor development, mouth hygiene, movement (physiology), neonatal intensive care unit, neuroimaging, physical examination, physical therapy modalities, physiotherapy, prematurity, preterm infant, qualitative research, stretching exercise, therapy effect, ventilator-associated pneumonia.
  - g. Cluster 7, represented in orange, comprises 21 items: abdominal pain, blunt trauma, body mass, clinical trial, complications, cycling, decompression surgery, early mobilization, early physiotherapy, elevated blood pressure, hypertensive factor, in-bed exercise, motor performance, neurosurgery, occupational therapy, outcome assessment, preliminary data, range of motion, spinal cord injuries, traumatology, and very early activity-based theory.
  - h. Cluster 8, represented in chocolate, comprises 13 items: assessment, cardiorespiratory physiotherapy, chronic patient, gas exchange, interrater reliability, mechanical ventilation, mobilization, multidisciplinary team, physiotherapist, rehabilitation, artificial respiration, respiratory care, and treatment.
  - i. Cluster 9, represented in pink, purple, comprises 13 items: exercise, extracorporeal life support, extracorporeal membrane oxygenation, extracorporeal oxygenation, ICU rehabilitation, motor activity, questionnaire, respiratory distress syndrome, respiratory physiotherapy, sedation, splinting, surveys and questionnaires, and walking.
  - j. Cluster 10, represented in pinks-orange items, comprises nine items related to chronic lung disease, clinical features, incidence, joint mobilization, neuromuscular blocking agent, predictor variable, articular range of motion, shoulder, and wakefulness.
  - k. Cluster 11, represented in green, comprises three items, such as hospital patients, patient mobility, and self-care.



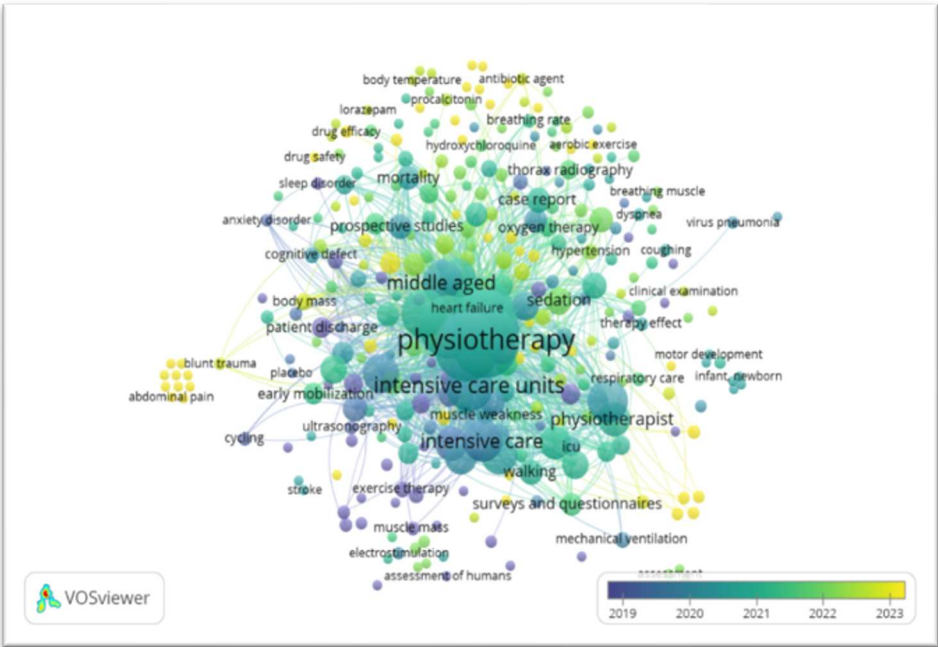


Figure 2. The Results of Overlay Visualization Analysis

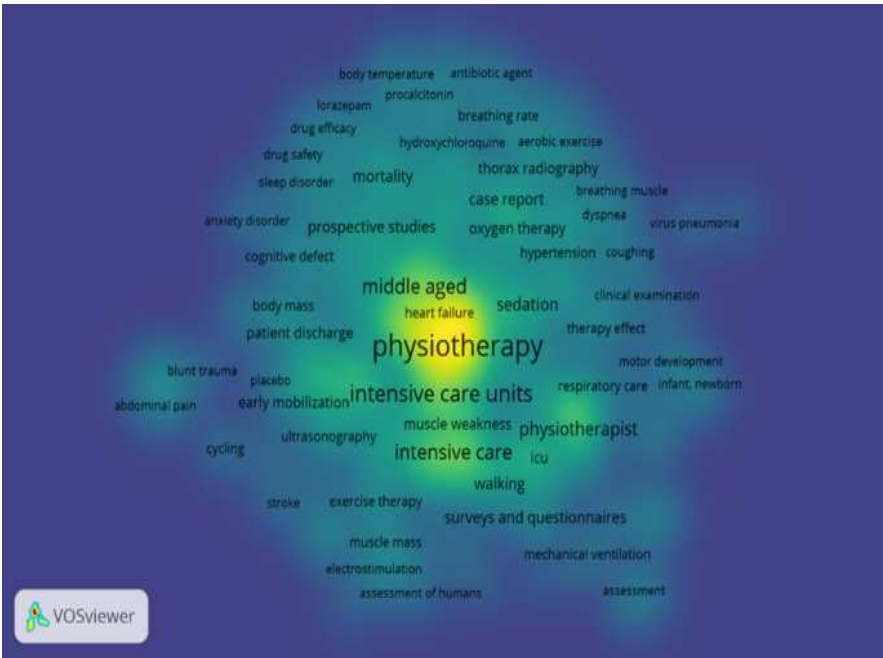


Figure 3. The Results of Density Visualization Analysis

### Figure 4. The Results of Network Visualization Analysis



The following table summarizes key information from the selected studies, including authors, publication year, research objectives, main findings, and relevance to early physiotherapy in critically ill ICU patients.

The overview highlights research trends, focus areas, and contributions of previous studies, providing the foundation for the present bibliometric analysis.

No	Author(s) & Year	Country	Journal	Study Type / Design	Main Focus / Keywords	Key Findings
1	(32)	UK	<i>Journal of Critical Care</i>	Observational study	Early mobilization; ICU recovery	Structured early rehabilitation for mechanically ventilated ICU patients is feasible and significantly accelerates mobility recovery.
2	(33)	UK	<i>Pilot and Feasibility Studies</i>	Experimental	High-risk ventilated patients	Early and intensified rehabilitation is feasible and may improve recovery outcomes.
3	(34)	USA	<i>Supportive Care in Cancer</i>	Survey	Cancer patients; early mobility	Ventilated cancer patients had positive early mobility experiences but exhibited memory impairment, requiring more patient-centered ICU care.
4	(35)	Australia	<i>Burns</i>	Retrospective observational cohort (5 years)	Burn survivors; sedation; mobilization	Optimal sedation and reduced sedative/inotropic use enhance early mobilization, supporting physiotherapy's role in functional recovery.
5	(12)	Australia	<i>Australian Critical Care</i>	Prospective observational study	Early mobilization; invasive mechanical ventilation	Early activity improves psychological well-being and muscle strength in ICU patients.
6	(15)	Italy	<i>Monaldi Archives for Chest Disease</i>	Review	COVID-19; early rehabilitation	Early physiotherapy in severe COVID-19 ICU patients is safe, feasible, and beneficial even when initiated later.
7	(3)	USA	<i>Annals of the American Thoracic Society</i>	Cross-sectional telephone survey	Early physiotherapy; physical activity	Early physiotherapy is more effectively implemented in large academic hospitals with established mobility protocols.
8	(17)	USA	<i>Chest</i>	Clinical trial	ICU-acquired weakness; early physiotherapy	Early mobilization may reduce ICU-acquired weakness and promote euglycemia as an alternative to intensive insulin therapy.
9	(18)	China	<i>International Heart Journal</i>	Experimental study	Coronary artery disease; rehabilitation	Early rehabilitation significantly reduces mechanical ventilation duration.
10	(29)	Brazil	<i>Fisioterapia em Movimento</i>	Observational study	Mobility; functional recovery; cardiac surgery	Early physiotherapy improves mobility from IMS 0 to IMS 7–10 by ICU discharge, even with 54.6% patients on vasoactive drugs.
11	(36)	Switzerland	<i>Swiss Medical Weekly</i>	Cross-sectional survey	Quality of life; psychological effects	Early physiotherapy improves physical function, accelerates recovery, and reduces negative effects of immobility during ICU stay.

## Early physiotherapy

Early physiotherapy is a form of maintenance physical therapy provided shortly after ICU admission with specific clinical objective.<sup>26</sup> Early physiotherapy is divided into two, early mobilization and early ambulation. Early mobilization involves therapeutic interventions administered within hours after surgery,<sup>50</sup> whereas early ambulation focuses on guiding patients to sit, stand, and walk as soon as medically feasible.<sup>1</sup> The literature indicates that early physiotherapy offers multiple benefits, including shortened ICU and hospital stays for patients with pneumonia and improved activities of daily living (ADL) outcomes.<sup>55</sup> Early rehabilitation using a cycle ergometer helps preserve knee extensor and diaphragm morphology in ICU patients with neuromuscular complications.<sup>1</sup> In post-operative cardiac patients, early physiotherapy can prevent respiratory complications by improving dyspnea, respiratory rate, and oxygen saturation.<sup>47</sup> It may also reduce the duration of mechanical ventilation and limit functional dependence in critically ill patients.<sup>56</sup> Overall, early physiotherapy has been demonstrated to be safe in ICU settings. In patients receiving Venous extracorporeal membrane oxygenation (ECMO), early initiation of therapy was associated with shorter ICU stays.<sup>57</sup> Early physiotherapy in the ICU has been shown to reduce both physical and psychological complications.<sup>11</sup> Among COVID-19 patients, early physiotherapy improved pulmonary secretion clearance, enhancing gas exchange, respiratory mechanics, and respiratory muscle function without adverse effects.<sup>58</sup> ICU patients receiving early physiotherapy were able to discontinue ventilatory support and supplemental oxygen sooner, improving functional outcomes and reducing ICU length of stay.<sup>59</sup> Additionally, early cardiac rehabilitation incorporating non-invasive ventilation and aerobic exercise accelerated recovery and reduced hospitalization in patients with heart failure.<sup>60</sup>

Early physiotherapy has been shown to be effective in addressing foot deformities such as calcaneal valgus, significantly improving leg alignment, leg length discrepancy (LLD), and gross motor development.<sup>61</sup> However, limitations exist; for

example, a single session of early physiotherapy did not significantly affect spontaneous movement in infants aged 12–16 weeks.<sup>62</sup> Early resilience training showed no measurable improvements in capacity, function, or independence, though it was associated with enhanced mental health up to six months' post-intervention.<sup>63</sup> Types of early physiotherapy in ICU settings include ventilator-assisted breathing exercises for pneumonia patients, cycle ergometer therapy to enhance muscle strength and rehabilitation, and physiotherapy for patients on venovenous extracorporeal membrane oxygenation (VV-ECMO) to reduce ICU stay. Additional interventions include positioning, active and passive exercises, breathing exercises, and chest percussion.

## Delayed physiotherapy

Delayed physiotherapy refers to interventions initiated after a patient has been admitted to the ICU but postponed until the patient achieves a certain level of clinical stability.<sup>64</sup> It is generally categorized into two aspects: functional status and muscle weakness. Functional status refers to a patient's ability to perform activities of daily living independently and safely<sup>65</sup>, which can be assessed through self-care, mobility, and overall independence during hospitalization. Muscle weakness, common among critically ill patients, including those recovering from stroke which represents a reduction in muscle strength and functional capacity.<sup>66</sup> The review indicates that physiotherapy enhances physical function and mitigates muscle weakness in critically ill patients. Available interventions include whole-body vibration therapy to stimulate muscle activity, as well as practical exercises designed to reduce muscle wasting.<sup>67</sup> Early sitting and upright training in ICU patients can accelerate stabilization and functional recovery.<sup>40</sup> Physiotherapy also promotes muscle activation during both active movement and rest.<sup>68</sup> Therapy using neuromuscular electrical stimulation (NMES) media helps increase patient muscle-critical abilities.<sup>50</sup> Intensive care physical therapy given to critically patient treated in the ICU can help improve muscle strength, muscle breathing, and functional parameters for patients during the treatment period.<sup>69</sup> Progressive mobility physiotherapy in patients can increase the activity level and its benefits in the

respiratory system, the system muscles, and the functionality of ICU patients.<sup>65</sup>

Functional status can be observed and analyzed through method analysis. Quantitative data can be collected through a questionnaire which is based on the results analysis in Figure 5. Meanwhile, exercise breathing and physical therapy modalities can improve the patient's muscle weakness. Breathing exercises for patients can increase cleaning channel respiration, alveolar recruitment, and maximization of gas exchange in the alveoli.<sup>70</sup> Therapists use physical therapy modalities to relieve pain or meditation in patients.<sup>71</sup> Research shows that mobilization physiotherapy can improve patients' functional status after leaving the ICU.<sup>72</sup> As for weaknesses in the application of delayed physiotherapy for critical patients in the ICU found in several cases, there was no significant comparison between patients who were given physiotherapy and those who were not given physiotherapy regarding forever-time maintenance patients.<sup>73</sup> Physique therapy with bad cycling does not reduce muscle reduction in patients' critical maturity. However, it still positively affects patients.<sup>74</sup> Types of physiotherapy that can be given to patients include exercising movement muscles with movement vibration all over the body in place sleep patient, giving therapy cycling in place sleep, until sitting and upright training for post-treatment critical patients.

Previous research indicates that physiotherapy remains underutilized in healthcare, particularly in Indonesia. Evidence demonstrates that physiotherapy can accelerate recovery, enhance physical function, and reduce mortality among critically ill patients in the ICU.<sup>75,76</sup> Although some studies report minimal differences between patients receiving physiotherapy and those who do not,<sup>77</sup> early physiotherapy generally provides greater benefits by promoting mobility and functional improvement. Advances in health technology have further supported this shift, showing that early physiotherapy leads to shorter ICU stays and fewer complications compared to delayed interventions.<sup>12</sup> These findings highlight the growing importance of adopting early physiotherapy as a standard approach in critical care management.

## CONCLUSION

The bibliometric analysis highlights the significant role of early physiotherapy in improving physical function, mental well-being, and overall recovery among critically ill patients in intensive care. The analysis identified six thematic clusters related to disease types, therapy methods, patient compliance, safety procedures, and recovery approaches, illustrating the broad and interdisciplinary scope of early physiotherapy research. The findings support initiating early physiotherapy upon ICU admission and continuing it throughout treatment and recovery to enhance long-term outcomes. Nonetheless, as this study is limited to bibliometric analysis with VOSviewer and lacks empirical validation, further clinical and quantitative research is needed to confirm its effectiveness and inform practical implementation.

## ACKNOWLEDGEMENT

The authors sincerely thank the editor for accepting the article for publication.

## REFERENCES

1. Santos LJ, Aguiar Lemos F, Bianchi T, Sachetti A, Acqua AMD, Silva Naue W, et al. Early rehabilitation using a passive cycle ergometer on muscle morphology in mechanically ventilated critically ill patients in the Intensive Care Unit (MoVe-ICU study): Study protocol for a randomized controlled trial. *Trials* [Internet]. 2015;16(1):4–9. Available from: <http://dx.doi.org/10.1186/s13063-015-0914-8>
2. Isyanto H, Muchtar H, Dinata AR. Design of Security System Device for Motorized Vehicles through the Telegram Messenger Application and Updating GPS Locations on Smartphones in Real Time with IoT-based Smart Vehicles. 2022;6(2):67–76.
3. Jolley SE, Dale CR, Hough CL. Hospital-level factors associated with report of physical activity in patients on mechanical ventilation across Washington State. *Ann Am Thorac Soc*. 2015;12(2):209–15.
4. Rollinson TC, Connolly B, Berlowitz DJ, Berney S. Physical activity of patients with critical illness undergoing rehabilitation in

- intensive care and on the acute ward: An observational cohort study. *Aust Crit Care* [Internet]. 2022;35(4):362–8. Available from: <https://doi.org/10.1016/j.aucc.2021.06.005>
5. Hiser S, Manthey E, Toonstra A, Friedman LA, Ramsay P, Needham DM. Physiotherapists' and Physiotherapy Assistants' Perspectives on Using Three Physical Function Measures in the Intensive Care Unit: A Mixed-Methods Study. *Physiother Canada*. 2022;74(3):240–6.
6. Berney SC, Rose JW, Bernhardt J, Denehy L. Prospective observation of physical activity in critically ill patients who were intubated for more than 48 hours. *J Crit Care* [Internet]. 2015;30(4):658–63. Available from: <http://dx.doi.org/10.1016/j.jcrc.2015.03.006>
7. Furnari D, Khan N, Delaney M, Hamlaoui K, Lagree S, Peace A, et al. Brain, Lagree Method, Manual Therapy; Physical Exercise, Microformer, Massage in Psycho-Body, Emotional-Affective and Socio-Relational Recovery. *J Addict Res*. 2021;5(2):135–42.
8. Morris PE, Berry MJ, Files DC, Thompson JC, Hauser J, Flores L, et al. Standardized rehabilitation and hospital length of stay among patients with acute respiratory failure a randomized clinical trial. *JAMA - J Am Med Assoc* [Internet]. 2016;315(24):2694–702. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84976350801&doi=10.1001%2Fjama.2016.7201&partnerID=40&md5=7400ea78f9c0d56b0bfbfc6a85828e05>
9. Bright L, Van Der Lee L, Hince D, Wood FM, Edgar DW. Quantification of the negative impact of sedation and inotropic support on achieving early mobility in burn patients in ICU: A single center observational study. *Burns* [Internet]. 2021;47(8):1756–65. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85116818234&doi=10.1016%2Fj.burns.2021.09.015&partnerID=40&md5=89efda329a203e7f68a31e1755088f91>
10. Qi W, Murphy TE, Doyle MM, Ferrante LE. associated Pneumonia among Critically Ill Patients. 2023;38(5):418–24.
11. Çakmak A, İnce Dİ, Sağlam M, Savcı S, Yağlı NV, Kütükcü EÇ, et al. Physiotherapy and rehabilitation implementation in intensive care units: A survey study. *Turkish Thorac J*. 2019;20(2):114–9.
12. Capell EL, Tipping CJ, Hodgson CL. Barriers to implementing expert safety recommendations for early mobilisation in intensive care unit during mechanical ventilation: A prospective observational study. *Aust Crit Care* [Internet]. 2019;32(3):185–90. Available from: <https://doi.org/10.1016/j.aucc.2018.05.005>
13. Barber EA, Everard T, Holland AE, Tipping C, Bradley SJ, Hodgson CL. Barriers and facilitators to early mobilisation in Intensive Care: A qualitative study. *Aust Crit Care* [Internet]. 2015;28(4):177–82. Available from: <http://dx.doi.org/10.1016/j.aucc.2014.11.001>
14. Holdsworth C, Haines KJ, Francis JJ, Marshall A, O'Connor D, Skinner EH. Mobilization of ventilated patients in the intensive care unit: An elicitation study using the theory of planned behavior. *J Crit Care* [Internet]. 2015;30(6):1243–50. Available from: <http://dx.doi.org/10.1016/j.jcrc.2015.08.010>
15. Rossi V, Santambrogio M, Del Monaco C, Retucci M, Tammaro S, Ceruti C, et al. Safety and feasibility of physiotherapy in ICU-admitted severe COVID-19 patients: An observational study. *Monaldi Arch Chest Dis* [Internet]. 2022;92(4). Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85124882260&doi=10.4081%2Fmonaldi.2022.2087&partnerID=40&md5=faced5ec9288b53edd7f72fa9cacf25>
16. Battaglini D, Caiffa S, Gasti G, Ciaravolo E, Robba C, Herrmann J, et al. An experimental pre-post study on the efficacy of respiratory physiotherapy in severe critically ill covid-19 patients. *J Clin Med*. 2021;10(10):1–12.
17. Patel BK, Pohlman AS, Hall JB, Kress JP. Impact of early mobilization on glycemic control and ICU-acquired weakness in critically ill patients who are mechanically ventilated. *Chest*. 2014;146(3):583–9.
18. Dong Z, Yu B, Zhang Q, Pei H, Xing J, Fang W, et al. Early rehabilitation therapy is beneficial for patients with prolonged mechanical ventilation after coronary artery bypass surgery a prospective random study. *Int Heart J*. 2016;57(2):241–6.
19. Weeks A, Campbell C, Rajendram P, Shi W, Voigt LP. A Descriptive Report of Early Mobilization for Critically Ill Ventilated Patients with Cancer. *Rehabil Oncol*. 2017;35(3):144–50.
20. Siesage K, Joelsson-Alm E, Schandl A, Karlsson E. Extended physiotherapy after Intensive Care Unit (ICU) stay: A prospective

- pilot study with a before and after design. *Physiother Theory Pract* [Internet]. 2024;40(6):1232–40. Available from: <https://doi.org/10.1080/09593985.2022.2143251>
21. de Cássia Artuni Rossi M, Corrêa TQ, Blanco KC, Bagnato VS, Salvio AG. Physiotherapy elastic band disinfection by UV-C irradiation in an intensive care unit. *Photodiagnosis Photodyn Ther*. 2021;34(March).
22. Burch D, Bernert S, Fraser JF. Increased physician and physical therapist communication is associated with earlier mobility and decreased length of stay in the cerebrovascular and trauma neuroscience population. *NeuroRehabilitation*. 2018;43(2):195–9.
23. Merino-Osorio C, Velásquez M, Reveco R, Marmolejo JJ, Fu C. 24/7 Physical Therapy Intervention With Adult Patients in a Chilean Intensive Care Unit: A Cost-Benefit Analysis in a Developing Country. *Value Heal Reg Issues* [Internet]. 2020;23:99–104. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85095454059&doi=10.1016%2Fj.vhri.2020.04.006&partnerID=40&md5=d5f0ad7331b488809c44ea60bbcac9ac>
24. Xu L, Li Y, He Y, Chen M, Zhang Y, Liu C, et al. Knowledge Mapping Analysis of Research on Pregnancy-Related Pelvic Girdle Pain (PPGP) from 2002 to 2022 Using Bibliometrics. *J Pain Res* [Internet]. 2024;17:643–66. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85185510603&doi=10.2147%2FJPR.S431438&partnerID=40&md5=f056aad56ba4b9301e49dfc90ca82a4a>
25. Yang M, Cho TY, Liu X, Dai Y. Research status and development direction of Child-Friendly Cities: a bibliometric analysis based on VOSviewer. *J Asian Archit Build Eng* [Internet]. 2023; Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85179942874&doi=10.1080%2F13467581.2023.2292082&partnerID=40&md5=69ca8c55bb8c3bcf8f6c1991ea84639b>
26. Rossi V, Santambrogio M, Del Monaco C, Retucci M, Tammaro S, Ceruti C, et al. Safety and feasibility of physiotherapy in ICU-admitted severe COVID-19 patients: An observational study. *Monaldi Arch Chest Dis*. 2022;92(4).
27. Rotolo D, Rafols I, Hopkins MM, Leydesdorff L. Strategic Intelligence on Emerging Technologies: Scientometric Overlay Mapping. *J Assoc Inf Sci Technol*. 2017;68(1):214–33.
28. Soto S, Adasme R, Vivanco P, Figueroa P. Efficacy of the «Start to move» protocol on functionality, ICU-acquired weakness and delirium: Randomized clinical trial. *Med Intensiva* [Internet]. 2024;48(4):211–9. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85183543729&doi=10.1016%2Fj.medin.2023.12.001&partnerID=40&md5=45b20a9771739a53553637901fec785f>
29. Lima LSS, de Medeiros Cardoso RA, dos Santos NP, de Almeida Silva BF, Borges MGB, Borges DL. Application of the ICU Mobility Scale in patients submitted to cardiac surgery. *Fisioter em Mov*. 2024;37.
30. Furstenau LB, Sott MK, Homrich AJO, Kipper LM, Dohan MS, López-Robles JR, et al. An Overview of 42 years of Lean Production: Applying Bibliometric Analysis to investigate strategic themes and scientific evolution structure. *Technol Anal Strateg Manag* [Internet]. 2021;33(9):1068–87. Available from: <https://doi.org/10.1080/09537325.2020.1865530>
31. Kumar S, Chavan M, Pandey N. Journal of International Management: A 25-year review using bibliometric analysis. *J Int Manag* [Internet]. 2023;29(1). Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85139261287&doi=10.1016%2Fj.intman.2022.100988&partnerID=40&md5=3dee28351e57c78304106628f8bcb4af>
32. McWilliams D, Jones C, Atkins G, Hodson J, Whitehouse T, Veenith T, et al. Earlier and enhanced rehabilitation of mechanically ventilated patients in critical care: A feasibility randomised controlled trial. *J Crit Care* [Internet]. 2018;44:407–12. Available from: <https://doi.org/10.1016/j.jcrc.2018.01.001>
33. Snelson C, Jones C, Atkins G, Hodson J, Whitehouse T, Veenith T, et al. A comparison of earlier and enhanced rehabilitation of mechanically ventilated patients in critical care compared to standard care (REHAB): Study protocol for a single-site randomised controlled feasibility trial. *Pilot Feasibility Stud*. 2017;3(1):1–9.
34. Hsu SH, Campbell C, Weeks AK, Herklotz M,



- Kostecky N, Pastores SM, et al. A pilot survey of ventilated cancer patients' perspectives and recollections of early mobility in the intensive care unit. *Support Care Cancer*. 2020;28(2):747–53.
35. Bright L, Van Der Lee L, Hince D, Wood FM, Edgar DW. Quantification of the negative impact of sedation and inotropic support on achieving early mobility in burn patients in ICU: A single center observational study. *Burns*. 2021;47(8):1756–65.
36. Tomonaga Y, Menges D, Yebyo HG, Fumeaux T, Heise A, Wesch C, et al. Early mobilisation and rehabilitation in Swiss intensive care units: A cross-sectional survey. *Swiss Med Wkly*. 2022;152(3).
37. Thomas P, Chaseling W, Marais L, Matheson C, Paton M, Swanepoel N. Physiotherapy services in intensive care. A workforce survey of Australia and New Zealand. *Aust Crit Care [Internet]*. 2023;36(5):806–12. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85144980280&doi=10.1016%2Fj.aucc.2022.11.004&partnerID=40&md5=ae065e7c2ecc9241a8b88cfe3b1f0ed5>
38. Tronstad O, Martí JD, Ntoumenopoulos G, Gosselink R. An Update on Cardiorespiratory Physiotherapy during Mechanical Ventilation. *Semin Respir Crit Care Med [Internet]*. 2022;43(3):390–404. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85129281807&doi=10.1055%2F-s0042-1744307&partnerID=40&md5=18fed674056b1d7fdf258a9f9a7a45aa>
39. Cebeci GC, Cebeci H, Kucuk MP, Kucuk AO, Bayrak IK, Ulger F. Neuromuscular Electrical Stimulator as a Protective Treatment against Intensive Care Unit Muscle Wasting in Sepsis/Septic Shock Patients. *J Coll Physicians Surg Pakistan*. 2022;32(10):1300–7.
40. Nickels MR, Aitken LM, Walsham J, Crampton LJ, Barnett AG, McPhail SM. Exercise interventions are delayed in critically ill patients: a cohort study in an Australian tertiary intensive care unit. *Physiother (United Kingdom) [Internet]*. 2020;109:75–84. Available from: <https://doi.org/10.1016/j.physio.2019.06.011>
41. Zwoliński T, Wujtewicz M, Szamotulska J, Sinoracki T, Wąż P, Hansdorfer-Korzon R, et al. Feasibility of Chest Wall and Diaphragm Proprioceptive Neuromuscular Facilitation (PNF) Techniques in Mechanically Ventilated Patients. *Int J Environ Res Public Health*. 2022;19(2).
42. Vitacca M, Barbano L, Vanoglio F, Luisa A, Bernocchi P, Giordano A, et al. Does 6-month home caregiver-supervised physiotherapy improve post-critical care outcomes? *Am J Phys Med Rehabil*. 2016;95(8):571–9.
43. Castro-Avila AC, Serón P, Fan E, Gaete M, Mickan S. Effect of early rehabilitation during intensive care unit stay on functional status: Systematic review and meta-analysis. *PLoS One [Internet]*. 2015;10(7). Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84940030301&doi=10.1371%2Fjournal.pone.0130722&partnerID=40&md5=69b4a2083963d33a0b76cde6bba841f1>
44. Grunow JJ, Goll M, Carbon NM, Liebl ME, Weber-Carstens S, Wollersheim T. Differential contractile response of critically ill patients to neuromuscular electrical stimulation. *Crit Care*. 2019;23(1):1–12.
45. Chiarici A, Andrenelli E, Serpilli O, Andreolini M, Tedesco S, Pomponio G, et al. An Early Tailored Approach Is the Key to Effective Rehabilitation in the Intensive Care Unit. *Arch Phys Med Rehabil [Internet]*. 2019;100(8):1506–14. Available from: <https://doi.org/10.1016/j.apmr.2019.01.015>
46. Corner EJ, Hichens L V., Attrill KM, Vizcaychipi MP, Brett SJ, Handy JM. The responsiveness of the Chelsea Critical Care Physical Assessment tool in measuring functional recovery in the burns critical care population: An observational study. *Burns [Internet]*. 2015;41(2):241–7. Available from: <http://dx.doi.org/10.1016/j.burns.2014.12.002>
47. Tariq MI, Khan AA, Khalid Z, Farheen H, Siddiqi FA, Amjad I. Effect of early ≤ 3 Mets (Metabolic Equivalent of Tasks) of physical activity on patient's outcome after cardiac surgery. *J Coll Physicians Surg Pakistan [Internet]*. 2017;27(8):490–4. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85029376977&partnerID=40&md5=8d4e283df6c7c12039b75a9ad7641311>
48. Brunner S, Mayer H, Blum K, Breidert M, Dietrich M, Dahl E, et al. Nutrition-related care needs of older patients in hospital: A qualitative multimethod study. *Int J Nurs Knowl*. 2023;34(2):148–60.
49. Brummel NE, Girard TD, Ely EW, Pandharipande PP, Morandi A, Hughes CG, et al. Feasibility and safety of early combined

- cognitive and physical therapy for critically ill medical and surgical patients: The Activity and Cognitive Therapy in ICU (ACT-ICU) trial. *Intensive Care Med.* 2014;40(3):370–9.
50. Wollersheim T, Grunow JJ, Carbon NM, Haas K, Malleike J, Ramme SF, et al. Muscle wasting and function after muscle activation and early protocol-based physiotherapy: an explorative trial. *J Cachexia Sarcopenia Muscle.* 2019;10(4):734–47.
51. Bordas-Martínez J, Luzardo-González A, Arencibia A, Tormo F, Matéu L, Vicens-Zygmunt V, et al. Effects of Early Physical Therapy and Follow-Up in Acute Severe Coronavirus Disease 2019 Pneumonia: A Retrospective Observational Study. *Front Med* [Internet]. 2022;9. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85128826357&doi=10.3389%2Ffmed.2022.866055&partnerID=40&md5=bf26485a866269f33d391aa9609cc1c9>
52. Elkbuli A, Fanfan D, Sutherland M, Newsome K, Morse J, Babcock J, et al. The Association Between Early Versus Late Physical Therapy Initiation and Outcomes of Trauma Patients With and Without Traumatic Brain Injuries. *J Surg Res* [Internet]. 2022;273:34–43. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85123172016&doi=10.1016%2Fj.jss.2021.11.011&partnerID=40&md5=1d3dfcbb0eee3dc5be4697f91171586>
53. Schmidt K, Worrack S, Von Korff M, Davydow D, Brunkhorst F, Ehlert U, et al. Effect of a primary care management intervention on mental health-related quality of life among survivors of sepsis a randomized clinical trial. *JAMA - J Am Med Assoc.* 2016;315(24):2703–11.
54. Swayngim R, Preslaski C, Dawson J. Use of Valproic Acid for the Management of Delirium and Agitation in the Intensive Care Unit. *J Pharm Pract* [Internet]. 2024;37(1):118–22. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85139070806&doi=10.1177%2F08971900221128636&partnerID=40&md5=d9708c9fd1824bc4c2283d21fe9cdb74>
55. Chigira Y, Takai T, Igusa H, Dobashi K. Effects of early physiotherapy with respect to severity of pneumonia of elderly patients admitted to an intensive care unit: A single center study in Japan. *J Phys Ther Sci* [Internet]. 2015;27(7):2053–6. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-84937877266&doi=10.1589%2Fjpts.27.2053&partnerID=40&md5=90aac30e4f5ac1680c7aca5c2f1673af>
56. Black C, Grocott M, Singer M. The oxygen cost of rehabilitation interventions in mechanically ventilated patients: an observational study. *Physiother (United Kingdom)* [Internet]. 2020;107:169–75. Available from: <https://doi.org/10.1016/j.physio.2019.06.008>
57. Bonizzoli M, Lazzeri C, Drago A, Tadini Boninsegni L, Donati M, Di Valvasone S, et al. Effects of a physiotherapeutic program in patients on veno-venous extracorporeal membrane oxygenation: An 8-year single-center experience. *Minerva Anestesiol* [Internet]. 2019;85(9):989–94. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85072142909&doi=10.23736%2FS0375-9393.19.13287-7&partnerID=40&md5=b24d09d2d336d06611d4a84cecc8dc29>
58. Ballesteros Reviriego G, Planas Pascual B, Rojo Ruiz A, Sánchez Romero EA, Corbelini C, Villafañe JH. Spanish Experience of Pulmonary Rehabilitation Efficacy for Patients Affected by the Novel SARS-CoV-2 (COVID-19): A Case Report. *Top Geriatr Rehabil* [Internet]. 2020;36(4):212–4. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85096788753&doi=10.1097%2FTGR.0000000000000283&partnerID=40&md5=c5c241b10982f527ae83c7a4ac94dad>
59. Mahesh AH, Mahadevan R, Krishnarao CS. Impact of Physiotherapy on Functional Status and Length of Stay of Patients Admitted to Intensive Care Unit. *Curr Respir Med Rev* [Internet]. 2022;18(4):267–74. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85142610669&doi=10.2174%2F1573398X18666220818095151&partnerID=40&md5=54777e10d07ee85510d639309e404cb4>
60. Di Leone CN, Diniz CP, Vieira de Araújo TM, Sant’ Anna MD, Lamas CDC, Mediano MFF, et al. Aerobic exercise simultaneous with non-invasive ventilation reduces the length of stay

- in intensive care in patients with heart failure: a randomised clinical trial. *Eur J Physiother* [Internet]. 2024;26(3):176–84. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85164506674&doi=10.1080%2F21679169.2023.2229392&partnerID=40&md5=f6d8d863b6215a5e4378d507e0803d3f>
61. Ferrara PE, Gatto DM, Bastoni I, Zordan P, Stefinlongo G, Marini R, et al. Rehabilitation of Children Affected by Congenital Posteromedial Bowing of the Tibia: A Case Report. *J Biol Regul Homeost Agents* [Internet]. 2022;36(3):769–74. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85144414467&doi=10.23812%2Fj.biol.regul.homeost.agents.20223603.84&partnerID=40&md5=80a9cf7401f553570eba6267d5c3152b>
  62. Varol BK, Tanrıverdi M, İşcan A, Alemdaroğlu-Gürbüz İ. The acute effects of physiotherapy on general movement patterns in preterm infants: A single-blind study. *Early Hum Dev* [Internet]. 2019;131:15–20. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85061660776&doi=10.1016%2Fj.earlhumdev.2019.02.004&partnerID=40&md5=615371e7175ca0ade1aa97f3eaa0aa64>
  63. Eggmann S, Irincheeva I, Luder G, Verra ML, Moser A, Bastiaenen CHG, et al. Cardiorespiratory response to early rehabilitation in critically ill adults: A secondary analysis of a randomised controlled trial. *PLoS One*. 2022;17(2 February):1–16.
  64. Jenkins TO, MacBean V, Poulsen MK, Karbing DS, Rees SE, Patel B V., et al. The metabolic cost of inspiratory muscle training in mechanically ventilated patients in critical care. *Intensive Care Med Exp* [Internet]. 2023;11(1). Available from: <https://doi.org/10.1186/s40635-023-00522-6>
  65. Schujmann DS, Teixeira Gomes T, Lunardi AC, Zoccoler Lamano M, Fragoso A, Pimentel M, et al. Impact of a Progressive Mobility Program on the Functional Status, Respiratory, and Muscular Systems of ICU Patients: A Randomized and Controlled Trial. *Crit Care Med*. 2020;48(4):491–7.
  66. Medrinal C, Prieur G, Bonnevie T, Gravier FE, Mayard D, Desmalles E, et al. Muscle weakness, functional capacities and recovery for COVID-19 ICU survivors. *BMC Anesthesiol*. 2021;21(1):1–5.
  67. Wollersheim T, Haas K, Wolf S, Mai K, Spies C, Steinhagen-Thiessen E, et al. Whole-body vibration to prevent intensive care unit-acquired weakness: Safety, feasibility, and metabolic response. *Crit Care* [Internet]. 2017;21(1):1–10. Available from: <http://dx.doi.org/10.1186/s13054-016-1576-y>
  68. Amundadóttir OR, Jónasdóttir RJ, Sigvaldason K, Gunnsteinsdóttir E, Haraldsdóttir B, Sveinsson T, et al. Effects of intensive upright mobilisation on outcomes of mechanically ventilated patients in the intensive care unit: a randomised controlled trial with 12-months follow-up. *Eur J Physiother* [Internet]. 2021;23(2):68–78. Available from: <https://doi.org/10.1080/21679169.2019.1645880>
  69. Yosef-Brauner O, Adi N, Ben Shahr T, Yehezkel E, Carmeli E. Effect of physical therapy on muscle strength, respiratory muscles and functional parameters in patients with intensive care unit-acquired weakness. *Clin Respir J*. 2015;9(1):1–6.
  70. van der Lee L, Hill AM, Patman S. A survey of clinicians regarding respiratory physiotherapy intervention for intubated and mechanically ventilated patients with community-acquired pneumonia. What is current practice in Australian ICUs? *J Eval Clin Pract*. 2017;23(4):812–20.
  71. Sousa ML de A, Coimbra VR de M, Takei MT, Melo CC de A, Feltrim MIZ, Nozawa E. Physiological abnormalities and adverse events during physical therapy in the intensive care unit after cardiac surgery: A prospective observational study. *Brazilian J Phys Ther*. 2021;25(5):623–31.
  72. Lorenz M, Fuest K, Ulm B, Grunow JJ, Warner L, Bald A, et al. The optimal dose of mobilisation therapy in the ICU: a prospective cohort study. *J Intensive Care* [Internet]. 2023;11(1):1–9. Available from: <https://doi.org/10.1186/s40560-023-00703-1>
  73. Johnson AM, Henning AN, Morris PE, Tezanos AGV, Dupont-Versteegden EE. Timing and amount of physical therapy treatment are associated with length of stay in the cardiothoracic icu. *Sci Rep* [Internet]. 2017;7(1):1–9. Available from: <http://dx.doi.org/10.1038/s41598-017-17624-3>
  74. Nickels MR, Aitken LM, Barnett AG, Walsham J, King S, Gale NE, et al. Effect of

- in-bed cycling on acute muscle wasting in critically ill adults: A randomised clinical trial. *J Crit Care* [Internet]. 2020;59:86–93. Available from: <https://doi.org/10.1016/j.jcrc.2020.05.008>
75. Dionne A, Cavayas YA, Magnuson D, Richard-Denis A, Petit Y, Barthélémy D, et al. Is it safe to initiate activity-based therapy within days following traumatic spinal cord injury? Preliminary results from the PROMPT-SCI trial. *J Spinal Cord Med* [Internet]. 2023;46(6):980–5. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85166753659&doi=10.1080%2F10790268.2023.2212329&partnerID=40&md5=86458e5e523ce0f4b448a23c53e5b516>
  76. Whitlock K, Rzewnicki D, Krieger B, Miller C, Creel-Bulos C. “Beyond waking and walking. Intensive rehabilitation in patients requiring extended durations of advanced mechanical circulatory support: A case series.” *Perfus (United Kingdom)* [Internet]. 2024;39(4):840–8. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85149475866&doi=10.1177%2F02676591231159570&partnerID=40&md5=7d9e8c75895f9c407a8106c7ff8528f8>
  77. Sousa MLDA, Coimbra VRDM, Takei MT, Melo CCDA, Feltrim MIZ, Nozawa E. Physiological abnormalities and adverse events during physical therapy in the intensive care unit after cardiac surgery: A prospective observational study. *Brazilian J Phys Ther* [Internet]. 2021;25(5):623–31. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85106499903&doi=10.1016%2Fj.bjpt.2021.04.001&partnerID=40&md5=ac4828b01edb276369138f5688b7bc67>