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NARRATIVE REVIEW



# Key principles for rehabilitation of critically ill patients with obesity

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## Abstract

**Purpose:** Patients with obesity who are admitted to an ICU bring specific challenges for rehabilitation during and after critical illness. This narrative review explores impact of differences in body compositions and pathophysiology on outcomes to summarise interprofessional, patient-centred rehabilitation strategies across the trajectory of recovery.

**Methods:** The interprofessional expert panel reviewed major trials and guidelines, integrating their clinical expertise with the current evidence.

**Results:** Three distinct phenotypes potentially influence outcomes for survivors. Whilst patients with preserved muscle mass may have a survival advantage, the phenotypes characterised by ectopic visceral fat or sarcopenia are frequently complicated by multimorbidity and polypharmacy, likely increasing the risk of adverse effects such as sub-optimal sedation, prolonged ventilation and immobilisation, malnutrition, and impaired recovery. Targeted respiratory interventions, including secretion-clearance techniques and appropriate patient positioning to prevent atelectasis, reduce the work of breathing. Optimisation of communication and swallowing function is an essential component for facilitating safe oral intake and promoting active patient participation in rehabilitation. Concurrently, targeted nutrition strategies combined with early, targeted, progressive mobilisation might mitigate ICU acquired weakness and support functional recovery. The availability of appropriate weight-based equipment is fundamental to ensuring safe mobilisation for both patients and healthcare professionals.

**Conclusion:** Interprofessional collaboration is central to optimising outcomes and should extend beyond the ICU to structured post-ICU follow-up to address persistent, worsening, or newly emerging health impairments. Early rehabilitation in critically ill patients with obesity should integrate physiological, logistical, and psychosocial considerations to support equitable and functional recovery.

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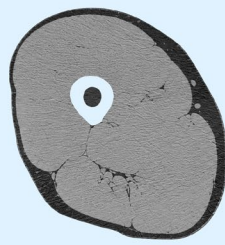
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## Visual abstract:

### KEY PRINCIPLES FOR REHABILITATION OF CRITICALLY ILL PATIENTS WITH OBESITY

A narrative review

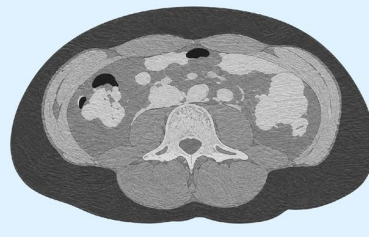
**BMI is a poor marker — Body composition is what matters.**



Thigh muscle

#### Obesity with preserved muscle mass

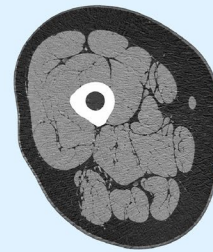
- Better physiological reserve
- Survival advantage
- Full rehabilitation possible



Abdomen

#### Obesity with ectopic visceral fat

- Metabolic comorbidities
- Individualized rehab to avoid overload



Thigh muscle

#### Sarcopenic obesity

- Worst outcome
- Frailty
- High ICU-acquired weakness risk

#### Findings

- **Obesity is not one phenotype:** distinguishing preserved muscle mass, visceral obesity, and sarcopenic obesity may fundamentally change rehabilitation strategies.
- **Rehabilitation starts on day 1:** respiratory support, nutrition, mobilisation, positioning, and communication should be integrated into a coordinated, multidisciplinary approach.
- **Beyond BMI:** body composition, frailty, and functional reserve are likely more relevant than BMI alone for predicting recovery and tailoring interventions.
- **From ICU to home:** structured post-ICU follow-up is essential to address physical, cognitive, psychological, and respiratory sequelae in this growing patient population.

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**Keywords:** Obesity, Critical care, Critical illness, Rehabilitation, Early ambulation

## Introduction

The prevalence of obesity is rising across the world, and critically ill patients with obesity are increasingly common in intensive care units (ICUs). The World Health Organisation (WHO) defines obesity as “excessive fat deposits” with a Body Mass Index (BMI) higher than 30 kg/m<sup>2</sup> [1]—although BMI is a poor marker for

body composition [2]. Weight bias—referring to negative beliefs and attitudes towards a person with obesity—can negatively affect ICU care [3], with healthcare professionals often perceiving patients as difficult, non-compliant [4], or even a threat to their own health due to a perceived risk for physical injuries [5]. In addition, multiple obesity-related physiological alterations,

including respiratory, cardiovascular, metabolic, and pharmacokinetic changes, present specific challenges in ICU management [6, 7], as discussed in detail below. Obesity does not confer protection against many types of adverse outcomes, despite some metabolic reserve from excess adiposity. Of particular concern is sarcopenic obesity, a condition with high body fat and low skeletal muscle, which is associated with poor outcomes [8]. Additional loss of muscle mass and function during the critical illness—termed ICU acquired weakness (ICUAW)—further increases long-term mortality and morbidity [9]. Rehabilitation of patients with obesity is therefore challenging, requiring optimal allocation of resources and collaboration across disciplines to enhance recovery.

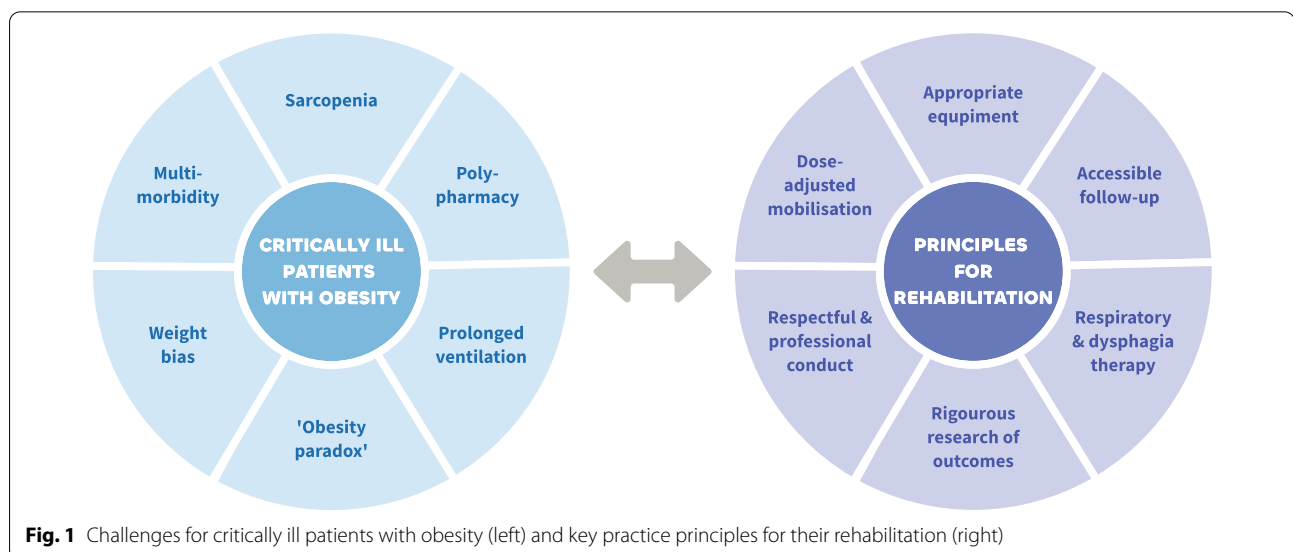
This narrative review discusses how interprofessional rehabilitation can be adapted to the altered pathophysiology of critically ill patients with obesity, considering body composition, pharmacokinetics and recovery trajectories for respiration, nutrition, positioning, early mobilisation, tracheostomy management, and follow-up (Fig. 1). Articles were reviewed non-systematically by an interprofessional expert panel up to 25 February 2026 and selected based on relevance, methodological quality, and clinical impact, integrating clinical expertise with current evidence. Overall, the level of evidence is low, with recommendations mostly based on expert opinion and clinical practice.

### Trajectory of recovery

Multicentre cohort studies in critically ill populations suggest that obesity may confer a short-term survival advantage, including a greater likelihood of discharge to home [10, 11]. The mechanisms causing this apparent ‘obesity paradox’ remain incompletely characterised and

are likely confounded by a combination of biological and methodological factors. These include age, medical or surgical conditions, frailty status, and body composition, wrongly classified by BMI. For instance, in a cohort of ICU patients with heart failure, the survival benefit associated with obesity was observed only amongst patients aged  $\geq 60$  years, highlighting potential age-related heterogeneity in the obesity survival relationship [12]. Selection bias might further influence earlier admission, closer monitoring or more aggressive treatment in patients with obesity, contributing to the ‘obesity paradox’ [6].

Other short-term outcomes appear less favourable in patients with morbid obesity. Extreme obesity (BMI  $\geq 40$  kg/m<sup>2</sup>) was associated with an increased incidence of delirium in a large retrospective analysis with 20,193 critically ill patients that adjusted for confounders [13]. Survivors with extreme obesity also seem to experience prolonged mechanical ventilation and extended ICU stays [14]. These issues are known risk factors for ICUAW [9]. In addition, the chronic inflammatory state associated with obesity may exacerbate muscle impairment during critical illness, increasing the risk of ICUAW [15]. However, despite these potential biological mechanisms, the independent influence of obesity on the development of ICUAW is not well understood, with some studies reporting a protective effect on muscle mass and strength through the metabolism of endogenous fat [16]. Similarly, the impact of obesity on functional recovery after critical illness is uncertain [17, 18]. In a recent multicentre observational study including 1,600 ICU survivors from 10 Brazilian ICUs, no association was observed between BMI categories and the physical component of health-related quality of life or functional independence [19].



**Fig. 1** Challenges for critically ill patients with obesity (left) and key practice principles for their rehabilitation (right)

## Phenotypes in obesity

Importantly, obesity can present with either preserved or reduced muscle mass and function. These differences in body composition may differentially influence patient outcomes with three distinct obesity phenotypes (Table 1) [20, 21]. Future research is required to investigate pragmatic bedside identification, which may include combining muscle ultrasound, waist circumference, a clinical frailty scale, and pre-ICU activities [21, 22]. The first phenotype includes persons with obesity and preserved muscle mass [20]. In a single-centre prospective observational cohort of 507 medical ICU patients at a US academic institution, a higher proportion of skeletal muscle mass (assessed by computed tomography scans at ICU admission) was associated with improved 6-month survival and a greater likelihood of discharge home with independent living [23].

The second phenotype is characterised by excess visceral adiposity irrespective of BMI. This type is commonly accompanied by ectopic fat deposition in the liver, heart, skeletal muscles, and other organs, which are potentially driving the associated metabolic complications (i.e., insulin resistance, glucose intolerance, dyslipidaemia, inflammation) and adverse cardiovascular outcomes [24]. This phenotype is prevalent in sedentary individuals, implying that individualised approaches to early mobilisation and exercise may be required to support patient participation, avoid overexertion, and foster positive training experiences in this previously inactive population (Table 1).

The third phenotype is termed sarcopenic obesity [21], which is associated with an increased short-term mortality, for example, in patients with abdominal sepsis [8].

Sarcopenic obesity can occur across age groups and is consistently linked to poorer functional and clinical outcomes in non-ICU populations [25]. Of relevance to ICU rehabilitation is the vicious circle of a previous sedentary lifestyle leading to weight gain, muscle loss and comorbidities [21]. Clinicians should be suspicious of a history of repeated falls, fatigability and recent illnesses or nutritional events. Whilst these patients commonly present with pre-ICU frailty, impaired mobility and physical function, and risk factors for ICUAW [9], the impact of sarcopenic obesity on long-term recovery after critical illness remains largely unstudied, underscoring the need for future ICU cohorts that incorporate measures of body composition and muscle function to clarify how obesity phenotypes influence post-ICU outcomes.

## Relevant pathophysiology

Obesity predisposes to a cascade of metabolic disturbances driven by adipokine-mediated low-grade inflammation, leading to insulin resistance, dyslipidaemia, and lipotoxicity. These processes increase the risk of type 2 diabetes, cardiovascular disease, malignancy, and liver disease [26]. Obesity nearly doubles the long-term risk of multimorbidity [27], which reduces physiological resilience to critical illness [28].

Pre-existing cardiorespiratory dysfunction is particularly relevant in the ICU. Obesity is a major risk factor for hypertension and both heart failure with preserved or reduced ejection fraction. Patients with obesity in the ICU have a higher risk of arrhythmias and obstructive sleep apnoea [7]. Abdominal adiposity reduces functional residual capacity and lung compliance, promoting airway closure and atelectasis; this necessitates tailored airway

**Table 1 Phenotypes of obesity with conceptual guidance for clinicians based on expert opinion**

| Phenotype                                     | Obesity with preserved muscle mass                                                                       | Obesity with ectopic visceral fat                                                                                                                         | Sarcopenic obesity                                                                      |
|-----------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Waist circumference <sup>a</sup>              | Normal                                                                                                   | High                                                                                                                                                      | High                                                                                    |
| Ectopic fat                                   | Low                                                                                                      | High                                                                                                                                                      | High                                                                                    |
| Lean mass                                     | High                                                                                                     | –                                                                                                                                                         | Low                                                                                     |
| Metabolic abnormalities                       | Absent                                                                                                   | Present                                                                                                                                                   | Present with chronic comorbidities                                                      |
| Lifestyle                                     | Active                                                                                                   | Sedentary                                                                                                                                                 | Sedentary                                                                               |
| Clinical frailty scale                        | Very fit (1)                                                                                             | Managing well (2–3)                                                                                                                                       | Vulnerable (≥ 4)                                                                        |
| Implications for physical rehabilitation      | Progressive physical rehabilitation to achieve full recovery                                             | Individualised approach to avoid overexertion and negative experiences associated with physical activity with goal to gradually support lifestyle changes | Pre-status as key driver for individualised approach to previous activity levels        |
| Ventilatory adjustments during rehabilitation | Consider patient's ability to increase oxygen supply to stimulate a training response before adjustments | Meet increased demands, to avoid overexertion and mismatch in oxygen balance to ensure tolerance of early mobilisation                                    | Adjust as need to meet increased demands, to allow functional and meaningful activities |

<sup>a</sup> Sex-based normative values: < 102 cm for males and < 88 cm for females [20]

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management and ventilatory strategies [29]. Obesity, particularly with the presence of excess visceral adipose tissue, can exert direct adverse effects on the myocardium and vasculature, compounded by obesity-associated comorbidities [30].

The pharmacokinetics and pharmacodynamics of medicines are significantly altered in obesity. Lipophilic medicines exhibit increased volume of distribution due to excess adipose tissue, while hepatic steatosis may reduce clearance, prolonging their effects and increasing the risk of accumulation. These principles are especially relevant for opioids and sedatives, requiring careful dosing and titration to reach the desired pain and sedation goals [31]. Hydrophilic medicines may conversely have reduced distribution and require adjusted dosing strategies.

Multimorbidity is closely linked to polypharmacy. Patients with obesity often present with extensive cardiovascular and antidiabetic medication regimens. Many medications are withheld during an acute critical illness, complicating their reintroduction for the management of both pre-existing and newly developed morbidities [32]. The combination of reduced physiological reserve, treatment burden, and complex medication management contributes to increased risk of deterioration and influences overall management during physical rehabilitation.

### **Respiratory care**

Obesity presents significant challenges for respiratory and ventilation management in the ICU. Patients with obesity typically exhibit obesity-related impairments in respiratory mechanics, including reductions in functional residual capacity and expiratory reserve volume, leading to an increased work of breathing, secretion retention, and ventilation–perfusion mismatches due to small airway closure [29]. These mechanisms, described above, are further exacerbated during critical illness and immobility, with pulmonary compliance reduced substantially as a result of increased pulmonary vascular pressures, chest wall mass, and cephalad displacement of the diaphragm due to the obese abdomen [33]. These physiological changes predispose patients with obesity to respiratory failure and complicate both non-invasive and invasive ventilatory strategies. Effective respiratory management requires an understanding of obesity-related pathophysiology and the application of tailored ventilatory approaches.

Initial respiratory support may involve non-invasive ventilation (NIV) or high-flow nasal cannula therapy to counteract atelectasis, reduce anatomical dead space, improve oxygenation, and decrease the work of breathing. Previous studies have provided moderate evidence that NIV may reduce the need for intubation and reduce

both morbidity and mortality compared with oxygen therapy alone [34, 35]. Alongside NIV, patient positioning plays a critical role in respiratory management [36]. Positioning patients in sitting or reverse Trendelenburg positions can reduce abdominal pressure, increasing functional residual capacity and allowing recruitment and aeration of dependent lung areas [37]. Hence, the supine position should be avoided; instead, timely mobilisation into an upright position may reduce atelectasis and ease recruitment of the accessory respiratory muscles [9]. When invasive mechanical ventilation is required, lung-protective ventilation strategies are paramount. Tidal volumes should be calculated based on ideal body weight (calculated based on sex and height), with higher levels of positive end-expiratory pressure (PEEP) often required to counteract significant reductions in functional residual capacity [38]. In cases of severe hypoxemia, prone positioning is feasible and may be effective in obese patients when performed by experienced teams, with extra attention merited for pressure injury prevention.

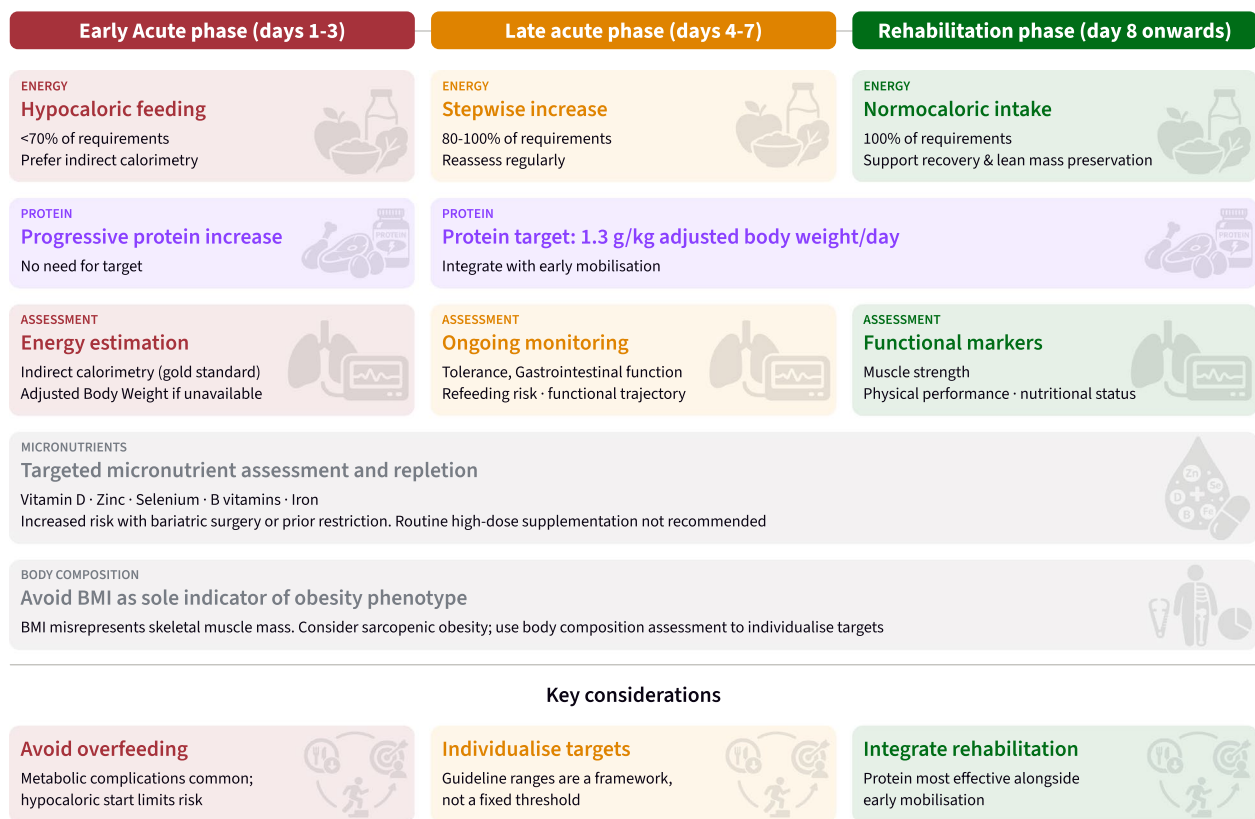
In patients with obesity who are receiving invasive mechanical ventilation, secretion-clearance mechanisms are significantly impaired. Underlying respiratory insufficiency, poor pulmonary compliance, and higher PEEP settings can increase the risk of retained secretions. Usual physiotherapy techniques, such as alternate side lying to facilitate postural drainage and manually assisted cough manoeuvres, are more challenging due to body size. Mechanical insufflation–exsufflation devices could be helpful to achieve adequate peak expiratory flow rates in these circumstances, along with early mobilisation to improve lung volumes [39].

Weaning and extubation may be prolonged due to increased work of breathing and respiratory muscle inefficiency. Programmes of early and structured rehabilitation are essential to support weaning and recovery. Inspiratory and expiratory muscle training may also be useful, although further studies are required in ventilated patients with obesity [40, 41]. There is high level of evidence for prophylactic NIV after extubation to decrease the risk of respiratory failure and reintubation, as well as mortality [42]. Consideration of pre-existing chronic comorbidities such as obesity, hypoventilation syndrome, or obstructive sleep apnoea further supports NIV in this population.

### **Tracheostomy care, communication, and swallowing**

Tracheostomy placement, communication, and swallowing difficulties can be more prevalent in those with obesity; however, evidence is variable. A key determinant in the placement of a tracheostomy tube is the need for prolonged mechanical ventilation. Patients with obesity may

## NUTRITIONAL MANAGEMENT IN CRITICALLY ILL PATIENTS WITH OBESITY



**Fig. 2** Nutritional management in critically ill patients with obesity

have increased duration of intubation with an endotracheal tube as observed in a cohort of 1307 patients, with a mean duration of 4 (1–9) days for those diagnosed as obese and 2 (1–6) days for those classified as non-obese ( $n=1082$ ) [43].

Tracheostomy complications can range from stoma/surgical site infection [44] to decreased success of decannulation [45]. Patients classified as obese are more likely to be diagnosed with laryngeal pathology, such as posterior glottic stenosis, subglottic stenosis, granulation tissue, and vocal fold immobility, thereby preventing decannulation (OR 3.1, 95%CI 1.4–6.6,  $p=0.004$ ) [45]. In addition to prolonged tracheostomy cannulation, the presence of these laryngeal pathologies can negatively impact patients' communication abilities due to disordered voice quality.

Dysphagia, or disordered swallowing, can significantly impact an individual's ability to safely and effectively consume oral intake. Although critically ill adults are at known significant risk of new dysphagia, increased BMI is associated with a slight reduction in the odds of dysphagia for those requiring mechanical ventilation [46].

However, more recent evidence has highlighted the increased risk of post-extubation dysphagia for patients with ICUAW, with those patients diagnosed with ICUAW having a significantly higher BMI at ICU admission [47]. The lack of evidence emphasises the importance of personalised patient assessments to identify rehabilitation needs for swallowing and communication, highlighting the necessity of evaluating these functions to determine each patient's specific rehabilitation requirements. Assessment and rehabilitation should be performed interprofessionally, including early access to speech and language therapists to optimise communication function and enable instrumental swallowing assessment [48]. Rehabilitation principles should address the sensory and motor functions of both respiratory and upper-airway muscles and set goals that consider the patient's function, activities, and participation [49].

### Nutrition interventions

Appropriate nutrition assessment and intervention are central to rehabilitation in critically ill patients with

| Equipment                                                                                                                                                                      | Purpose                                              | Specifications                                                                                                           | Rationale for rehabilitation                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Bariatric bed</b><br>                                                                      | Support safe positioning and in-bed mobilisation     | Weight capacity >250kg, width (>91cm), adjustable height, option to tilt into sitting/standing position, bariatric scale | Patient comfort, enables safe patient handling including early verticalisation or turning, facilitates in-bed rehabilitation, accurate weight measurement to assess the weight capacity of other equipment |
| <b>Pressure-redistributing mattresses</b><br>                                                 | Pressure injury prevention                           | Support surface that redistributes pressure, reduces shear and supports microclimate                                     | Protects skin integrity during immobility, avoids heat and moisture trapping, reduces risk of pressure injuries                                                                                            |
| <b>Lifts or hoists</b><br>                                                                    | Transfers or repositioning                           | Weight capacity >250kg, compatible with bariatric slings                                                                 | Reduces injury risk for healthcare professionals, enables safe mobilisation in severely weak patients                                                                                                      |
| <b>Slide sheets or transfer devices</b><br>                                                  | Transfers or repositioning                           | Low-friction surfaces that ease gliding                                                                                  | Reduces manual handling strain and shear for repositioning or transfers out-of-bed                                                                                                                         |
| <b>Bariatric chairs</b><br>                                                                 | Supported sitting                                    | Weight capacity >250kg, wide seat                                                                                        | Facilitates functional activities and independence                                                                                                                                                         |
| <b>Mobility aids (e.g. standing hoists, walker)</b><br>                                     | Early ambulation                                     | Weight capacity >250kg, reinforced frame                                                                                 | Facilitates functional activities and independence                                                                                                                                                         |
| <b>Training tools (e.g. elastic bands, weights, pulley, respiratory muscle trainer)</b><br> | Functional exercises and respiratory muscle training | Adjustable weights starting from 0.5kg; Respiratory muscle devices (threshold or electronic based)                       | Gradual progression of functional training exercises for in or out-of-bed<br>Inspiratory and expiratory muscle training with daily repetitions starting from 30% of maximal strength                       |

**Fig. 3** Bariatric equipment options for the rehabilitation of critically ill patients with obesity. The conceptual illustrations were created by the authors using generative artificial intelligence (version GPT-5.2)

obesity (Fig. 2). Critical illness accelerates catabolism and anabolic resistance, and emerging evidence suggests that patients with greater fat mass have more pronounced skeletal muscle loss compared with their lean counterparts [50]. This underscores the importance of targeted

nutrition strategies to prevent severe ICUAW and support functional recovery [51].

Accurate calculation of energy requirements is particularly challenging in patients with obesity. Use of actual body weight risks overfeeding, while ideal body weight

may underestimate requirements. Further, utilising BMI alone to classify obesity risks misrepresents skeletal muscle mass [50], a primary determinant of energy expenditure. For these reasons, indirect calorimetry remains the gold standard for determining energy expenditure [52] and should be used where available, as predictive equations perform poorly in this population [53]. Where indirect calorimetry is unavailable, current ESPEN guidelines recommend weight-based estimates using adjusted body weight as a pragmatic alternative with regular reassessment as clinical status evolves [52]. Hypocaloric feeding strategies during the acute phase (<70% of measured or estimated requirements), transitioning to normocaloric feeding (100% of requirements) during rehabilitation, may help preserve lean mass while minimising metabolic complications, although research targeted to patients with obesity remains limited. Whilst higher protein provision has not been shown to be beneficial in this population [54], adequate protein intake (1.3 g/kg adjusted body weight/day achieved progressively over the first week of critical illness [52]) integrated with early mobilisation and resistance-based rehabilitation may improve muscle protein synthesis and functional recovery, although definitive outcome data are not yet available. These targets represent a range within which clinicians should exercise judgement based on tolerance, clinical trajectory, and available monitoring, rather than a prescriptive threshold applied uniformly.

Micronutrient deficiencies are common in critical illness and may be exacerbated in specific obesity phenotypes associated with reduced intake and altered absorption. Deficiencies in vitamin D, zinc, selenium, B vitamins, and iron can impair muscle function, immune recovery, and rehabilitation capacity. Routine high-dose supplementation is not generally recommended, but targeted assessment and repletion are appropriate in prolonged ICU stays and post-ICU rehabilitation.

### Pressure injury prevention

Monitoring for pressure injuries in critically ill patients with obesity should begin immediately after ICU admission incorporating a structured risk assessment, skin inspection, and care [55]. Support surfaces with pressure redistribution and microclimate control is equally important for patients with obesity who are vulnerable to heat and moisture trappings [55]. Regular repositioning is recommended to reduce the risk of pressure injuries (based on moderate-to-strong evidence) [36, 55]. Thereby, a sufficiently wide surface is required to safely turn patients (>91 cm for patients with a BMI>35; >127 cm for patients with a BMI>45) (Fig. 3) [55]. In addition, each ICU should have adequate equipment that eases manual

handling, reduces friction and shear, and sufficiently supports patients in maintaining their position [55].

### Early physical rehabilitation including mobilisation

Early mobilisation can reduce the odds of developing ICUAW (OR 0.45 [95% CI 0.26–0.77]) [9], shorten the duration of delirium (mean difference – 1.34 days [95% CI – 1.85 to – 0.83]) and mechanical ventilation (1.07 days [95% CI – 1.64 to – 0.50]) [56], and improve survivors' physical function up to 6 months [57]. Current guidelines (strong to conditional recommendations) recommend individualised early mobilisation for all critically ill patients, commencing within the first 72 h of ICU admission [36, 58]. However, the evidence for critically ill patients with obesity is less certain, as many trials, including landmark trials [59–61], do not report subgroup details. Despite these limitations, early ambulation can be safe and feasible even in patients who are morbidly obese (BMI ≥ 40) [62].

Early mobilisation is generally progressed from in-bed exercises in supine or sitting position to functional, out-of-bed activities such as sitting on the edge of the bed, standing, or walking [36, 63]. Progression should be individualised, based on patients' prehospital function and cardiorespiratory reserve using established safety criteria, yet the optimal dose of mobilisation (i.e., frequency, duration, intensity) remains poorly understood [9]. This is particularly relevant for the mobilisation of critically ill patients with obesity, where the risks and benefits must be carefully evaluated individually for each patient [58]. Due to their distinct characteristics, close monitoring of cardiorespiratory parameters is key. For example, an exploratory analysis of cardiorespiratory parameters during and after 716 mobilisation sessions highlighted an increased risk for hypotension in patients with an elevated BMI. Importantly, the critical care team should be aware that hypotension is most likely to occur during the recovery phase, i.e., within 15 min after mobilisation [64].

Right-ventricular dysfunction is commonly present in patients with obesity due to underlying cardiovascular comorbidity, but may further limit exercise tolerance and contribute to haemodynamic instability [65]. Similarly, in patients with diabetes, a common diagnosis for patients with obesity, a high dose of early mobilisation was associated with an increased mortality in a secondary analysis; therefore, caution is warranted [66]. Notably, approximately 40% of the 750 patients in this study had a BMI > 30 [61]. The subsequent meta-analysis did not find an increase in adverse events or mortality; thus, low-dose, progressive, and individually adjusted early mobilisation is likely safe in this population [67]. More concerning might

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be the delay in the mobilisation of critically ill patients with obesity [68], risking muscle loss and dysfunction [9]. Early mobilisation and repositioning can be challenging due to patients' excessive weight, combined with ICUAW and well-recognised organisational and logistical barriers, including sedation, staffing constraints, weight bias, and limited access to appropriate bariatric equipment [55, 69, 70]. The experience of weight bias can lead patients to mistrust with increased fear of falling and ultimately patient refusal [55]. In contrast, healthcare professionals fear personal injury and fatigue [5, 55]. Early mobilisation in critically ill patients with obesity, therefore, requires a careful approach that includes the patient, interprofessional team, and adequate equipment and training to make the intervention feasible and safe. Regular assessment and goal setting should start early to avoid delays and to coordinate efforts [71]. Early consideration will also allow the timely organisation of necessary equipment, such as lifters, bariatric chairs, and beds [72] (Fig. 3). Before its use, equipment must be checked for the appropriate weight capacity, and healthcare professionals should complete necessary training to familiarise themselves with the device to ensure safe handling. This is particularly important when equipment is rented or if team training is not regularly conducted. Many beds offer auxiliary functions, such as a tilt-table, that allow for early upright positioning, potentially easing the work of breathing and reducing the burden on staff. Robotics might play a role in the future, yet research remains very limited, and to date, preliminary studies have been unable to show a reduction in the number of healthcare personnel required [73, 74]. In the end, positioning and early mobilisation will depend on sufficient staffing, education against discrimination, team training in ergonomic mobilisation, and appropriate equipment to facilitate implementation [38, 55].

Finally, as discussed earlier, patients with obesity often have increased work of breathing even at rest. The decision to commence more active mobilisation may require consideration of tailored respiratory adjustments (Table 1), such as increased respiratory support, to meet increased oxygen demands and to ensure tolerance of early mobilisation [38, 75]. Ventilatory adjustments should be individualised as excessive levels may induce ventilator-induced lung injury or precipitate haemodynamic compromise, particularly in patients with obesity-related cardiac dysfunction. However, data on how to optimise ventilatory support are limited, with observational studies indicating that early mobilisation may induce lung recruitment and improve oxygenation [76].

### Follow-up

Admission to an ICU and surviving a critical illness may have a substantial impact on both short- and long-term

quality of life [77]. Health-related impairments across the physical, cognitive, psychological, and social domains are collectively referred to as post-intensive care syndrome (PICS) [78], with an estimated pooled prevalence of 50% during follow-up within 1 month of ICU discharge [79]. In patients with obesity, physical impairments, such as muscle weakness, reduced mobility, and fatigue, may be masked or erroneously attributed to pre-existing obesity, leading to under-recognition of PICS. Moreover, a lower health-related quality of life in the mental component compared with normal-weight patients has been reported [19]. Rehabilitation planning and structured ICU follow-up may be valuable for detecting PICS-related symptoms in ICU survivors with obesity [80].

Rehabilitation after the ICU should account for pre-existing chronic cardiorespiratory comorbidities, as outlined above, which substantially influence recovery trajectories. Particularly, obesity hypoventilation syndrome and obstructive sleep apnoea with home NIV are highly prevalent in this cohort, potentially impairing ventilatory reserve, sleep quality, and participation in physical rehabilitation [81]. Failure to integrate cardiorespiratory assessment and management of these conditions risks suboptimal rehabilitation progression, increased fatigue, and a higher risk of readmission. A more comprehensive, multidisciplinary approach that incorporates respiratory support planning, management of sleep-disordered breathing, and assessment of cardiac function is therefore essential to deliver safe, individualised, and effective rehabilitation for patients with obesity recovering from critical illness.

In patients with obesity, interpretation of post-ICU functional recovery can be challenging, particularly when pre-morbid limitations are present. A staged follow-up approach may be considered [82], with a pragmatic threshold for reassessment and referral based on clinical need. In this context, ICU follow-up may be regarded not merely as an evaluative process but also as an early predictive tool for identifying patients in need of further rehabilitative support [83]. Although specialised in-person follow-up for ICU survivors with obesity is largely absent, and structured post-ICU assessment and support remain poorly developed, highlighting a clear need for targeted pathways. ICU follow-up provides an important setting to evaluate functional impairments in relation to obesity-related baseline limitations and post-ICU sequelae [84]. For example, previous home NIV settings might need adjustment or optimisation. Nevertheless, the ability to reliably differentiate pre-existing from new or worsened impairments is currently limited, highlighting the need for more robust approaches to assess pre-morbid functional status [82].

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Psychosocial factors warrant particular attention in patients with obesity. Feelings of shame or prior negative healthcare experiences may contribute to underreporting of symptoms and avoidance of care [3, 85]. A proactive, non-judgmental approach, with explicit normalisation of PICS-related symptoms, seems essential to overcome these barriers and to facilitate timely access to appropriate interventions. To this end, digital health applications may ease follow-up for patients with obesity, offering low thresholds for safe interactions with healthcare professionals and solutions in cases of limited mobility that impede regular hospital visits. Telemedicine and app-based monitoring may lower barriers due to perceived weight bias, improve accessibility, support longitudinal assessment of recovery, and enable timely intervention [86, 87]. ICU follow-up for patients with obesity should be embedded within an interprofessional framework, with early collaboration amongst doctors, nurses, rehabilitation clinicians, dietitians, pharmacists, and psychosocial care providers [88]. The primary objective of such follow-up should not be weight reduction, but rather the restoration of physical, mental, and cognitive functioning, with a focus on overall quality of life. This approach may help prevent undertreatment and may more effectively address the complex recovery needs of ICU survivors with obesity.

### Current challenges

Rehabilitation of critically ill patients with obesity is characterised by several interconnected challenges (Fig. 1). First, clinical complexity arises from multimorbidity, altered respiratory mechanics, and reduced physiological reserve, which complicate mobilisation, weaning, and recovery trajectories. Second, evidence gaps remain substantial, as critically ill patients with obesity are under-represented in rehabilitation trials and subgroup analyses are rarely reported. Third, logistical barriers, including limited availability of bariatric equipment, increased staffing requirements, and concerns regarding staff safety, frequently delay or limit mobilisation. Fourth, psychosocial factors such as weight bias may further hinder rehabilitation. Finally, the heterogeneity of obesity phenotypes, particularly sarcopenic obesity, is insufficiently captured in current clinical practice, limiting the ability to individualise interventions.

### Future directions

Future research should prioritise the inclusion of patients with obesity in critical care trials and ensure systematic reporting of this subgroup. A key priority is the development of phenotype-driven approaches that incorporate body composition, muscle function, and frailty. Further

work is needed to define optimal dosing, timing, and modality of rehabilitation interventions tailored to obesity-specific physiological constraints. The integration of respiratory support strategies with mobilisation protocols is another important area of investigation, particularly in critically ill patients with obesity. In addition, implementation research addressing logistical barriers, including equipment, staffing models, and training, is essential to translate evidence into practice. Finally, structured post-ICU pathways, including digital and telemedicine-supported follow-up, should be developed and evaluated to address long-term impairments and improve continuity of care.

### Conclusions

Despite the global increase in critically ill patients with obesity, this group remains marginalised and significantly under-researched, with limited evidence to inform rehabilitation practices. Key knowledge gaps include a better understanding of short- and long-term outcomes, ranging from the 'obesity paradox' to survivorship trajectories that encompass physical, mental, cognitive, and social health. Key research priorities include identifying obesity-specific phenotypes, treatment responders, as well as the optimal timing, dose, type, and adaptation of rehabilitation interventions across the continuum of recovery [9].

Optimising rehabilitation outcomes in this population likely requires early, tailored, and interprofessional approaches (Box 1). Adequate respiratory support, including NIV and positioning, should be implemented early to address obesity-related respiratory limitations and optimise lung recruitment, reduce the work of breathing, and minimise weaning failure. Patients with obesity are also at increased risk of laryngeal and upper-airway pathology, necessitating individualised assessment and management of communication and swallowing. Nutritional strategies should prioritise the preservation of muscle mass and function by using indirect calorimetry or adjusted body weight to guide energy provision, ensuring adequate protein delivery in line with the current guidelines, and addressing potential micronutrient deficiencies, particularly in emerging phenotypes of sarcopenic obesity. Early mobilisation should be initiated promptly, with careful consideration of obesity-related risks and barriers. Interventions should be individually adapted, progressing from in-bed exercises to functional activities such as sitting and standing. Successful implementation requires close interprofessional collaboration, staff training, and access to appropriate bariatric equipment. Beyond the ICU, structured follow-up is essential. Particular attention should be paid to psychosocial health, with flexible and accessible follow-up models to

identify post-ICU sequelae while accounting for pre-existing comorbidities and functional limitations.

In summary, there is an urgent need for obesity-inclusive rehabilitation research and guideline development in critical care. Future studies must intentionally include and report on patients with obesity, adopt phenotype-driven and outcomes-focussed designs, and evaluate tailored interventions across the entire recovery pathway to ensure equitable, effective, safe, and person-centred rehabilitation for this patient population.

**Box 1. Key principles for rehabilitation of critically ill patients with obesity.**

|                                  |                                                                                                                                                                                                                                  |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Trajectory of recovery           | Outcomes of physical, mental, and cognitive health for patients with obesity remain uncertain ranging from an apparent benefit ‘obesity paradox’ to an increased rate of complications                                           |
| Phenotypes                       | Potential relevant phenotypes for targeted, individualised rehabilitation include: (1) obesity with preserved muscle mass, (2) obesity with ectopic visceral fat, and (3) sarcopenic obesity                                     |
| Pathophysiology                  | Cardiorespiratory dysfunction is common in patients with obesity and requires adjusted rehabilitation with close monitoring of activities and rest. Exercise may have a positive impact on metabolic disturbances                |
| Respiratory care                 | Non-invasive ventilation or high-flow nasal cannula therapy should be considered before and after invasive ventilation. Secretion clearance techniques and sitting positions potentially reduce atelectasis and ease recruitment |
| Communication & swallowing       | The risk of laryngeal pathology may be increased; a personalised patient assessment may identify rehabilitation needs to optimise both swallowing and communication                                                              |
| Nutrition                        | Targeted nutrition strategies may help to preserve muscle mass, but need to be adjusted carefully to avoid over- or under-dosing                                                                                                 |
| Positioning & early mobilisation | Progression from in-bed to sitting to out-of-bed exercises should be individualised with close monitoring of cardiorespiratory parameters, the use of adequate equipment and consideration of pre-ICU lifestyle                  |
| Follow-up                        | A proactive, non-judgmental approach may help to address the complex recovery needs of ICU survivors with obesity                                                                                                                |

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**Data availability**

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**Declarations**

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