

## Research Article

# Functional Mobility in Mechanically Ventilated Critically ill Patients: An Observational Study

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- Mechanical ventilation

**Abstract**

**Objective:** The aim of this study was to describe the functional mobility (FM) both on awakening and at intensive care unit (ICU) discharge. Secondly, it aimed to explore the correlation between FM with deep sedation, mechanical ventilation, ICU delirium and absolute bed rest.

**Materials and Methods:** A descriptive study was performed in a medical and surgical ICU for one year among mechanically ventilated patients with previous functional independence. The FM was assessed with the Functional Status Score for the Intensive Care Unit (FSS-ICU) on awakening and at ICU discharge. Limb strength was assessed with the Medical Research Council Sum Score (MRC SS).

**Results:** From the 80 patients analyzed, the FSS-ICU resulted with 17 points on awakening and 26 points at ICU discharge. Exploration between FSS-ICU on awakening and deep sedation showed a negative correlation ( $\rho=0.39$ ;  $p=0.000$ ). Exploration between the FSS-ICU at ICU discharge and days on mechanical ventilation showed a negative correlation ( $\rho=0.36$ ;  $p=0.001$ ), as well as the presence of ICU delirium ( $\rho=0.25$ ;  $p=0.027$ ) and days with absolute bed rest ( $\rho=0.31$ ,  $p=0.005$ ). When exploring the presence of intensive care unit acquired weakness (ICU-AW) on awakening and the number of days under deep sedation, there was a statistically significant association (odds ratio = 0.1 [95% CI 0.035 to 0.275]).

**Conclusions:** Approximately one in four patients had ICU-AW and one in five patients were discharged from the ICU without being able to walk or with complete assistance.

**ABBREVIATIONS**

FM: Functional Mobility; s5Q: Standardized 5 Questions Scale; CAM-ICU: Confusion Assessment Method for the ICU; MRC SS: Medical Research Council Sum Score; FSS-ICU: Functional Status Score for the Intensive Care Unit; MIP: Maximum Inspiratory Pressure/Force; NMES: Neuromuscular Electrical Stimulation; ICU: Intensive Care Unit; ARDS: Acute Respiratory Distress Syndrome; COPD: Chronic Obstructive Pulmonary Disease; APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU-AW: Intensive Care Unit-Acquired Weakness

**INTRODUCTION**

Patients in intensive care units (ICU) remain hospitalized for a long time, leading to physical deterioration and the onset of health complications [1,2]. This is due to prolonged mechanical ventilation, deep sedation, high severity of illness at admission, delirium, prolonged bed rest, among others. These factors contribute to impaired functional status, causing physical, psychological and cognitive sequelae [3]. One of the syndromes that are commonly associated with the deterioration of functional

status is the intensive care unit acquired weakness (ICU-AW). The ICU-AW is defined as the symmetric weakness of extremities acquired by factors associated to ICU stay, affecting from 25% to 50% of critically ill patients[1].

Currently, the assessment of functional status has taken up relevance in clinical studies as it is considered an important indicator in the decision-making process in healthcare [4,5]. Functional status considers the quality and quantity of daily activities a person can do consciously. Among them is the mobility of the whole body, which includes transfers, maintenance of posture and walking? The performance of these activities is one of the main goals in physiotherapy intervention [6], which is named by some authors as “functional mobility” (FM) [6,7]. All of these activities associated with mobility are codified in Chapter 4 of Activities and Participation (d4) of the International Classification of Functioning, Disability and Health (ICF)[7].

The importance of maintaining and recovering the FM during ICU stay is to prevent the negative effects after ICU stay. These are related to the productivity of survivors after hospital discharge, delaying their return to work and to family duties, decreasing

the availability of hospital beds and ultimately raising healthcare costs [8-10]. It is therefore relevant to obtain an assessment and approach on FM in critically ill patients in an early and opportune manner [11,12]. Functional mobility of patients is usually low on awakening and at ICU discharge [13], causing functional problems after the ICU stay [14].

Physiotherapy has progressively been incorporated in Chile as part of the interdisciplinary ICU team [15] and plays an important role in facilitating activity. However, in Chile the ICU FM levels and its association with different risk factors are unknown, like in many other countries. The aim of this study was to describe the FM both on awakening and at ICU discharge in two ICUs in Chile. Secondly, it aimed to explore the correlation of FM with the days under deep sedation, days on mechanical ventilation, presence of ICU delirium and total days with absolute bed rest. In addition, the association between the presence of ICU-AW on awakening and the days under deep sedation was explored. The hypothesis of the present study is that the FM measured through FSS-ICU has more than 5 points of change from ICU awakening to ICU discharge [13,16].

## MATERIALS AND METHODS

Patients were admitted to medical and surgical ICU of Clínica INDISA from March 2<sup>nd</sup>, 2015 to March 2<sup>nd</sup>, 2016. This ICU had 2 units of 8 beds each, with university affiliation and acted as teaching centers. The inclusion criteria to participate in the study were: 1) 48 or more hours on invasive mechanical ventilation [IMV] or non-invasive ventilation; 2) 72 or more hours on ICU stay; and 3) prior functional independence defined by Karnofsky Performance Scale (KPS) [17] > 70%. The exclusion criteria are shown in the flow reference diagram on Figure 1. This study was approved by the Ethics Committee Servicio Metropolitano Oriente, Santiago, Chile (N°CECOriente-161214) on December 2014. All the included patients or their legal representative signed an informed consent before the study initiated.

To avoid potential sources of bias, six trained physiotherapists recorded the daily assessment results from the scales on a sheet of operational control, specifying the presence or absence of risk factors suggested by the literature and sociodemographic data. They also registered the medical indication for physiotherapy, which is given by the physician on a daily basis to all patients requiring mechanical ventilation. The physiotherapy session included passive mobilization, positioning and progressive FM facilitation. In the center selected for the study, physiotherapists are responsible for respiratory therapy, too. The duration of physiotherapy ranged from 60 to 120 minutes per 12 hours for each ICU patient according to the Physiotherapy Daily Assessment [Supplementary material 1]. Currently there is no formal clinical practice guide for mobilizing patients in the center, thus the intensity and progression depend on each physiotherapists. Sedation, glycemia and mechanical ventilation weaning protocols are routinely used. The sedation protocol includes light sedation and a daily wake-up trial.

### Assessments

The severity of illness of the first 24 hours was assessed using the Acute Physiology and Chronic Health Evaluation II (APACHE II) [18]. This scale has a score that ranges point from 0 – 71.

On awakening, defined as the first time that the patient was able to answer 5 simple orders (Standardized Five Questions - s5Q) [1], the Medical Research Council Sum Score (MRC SS) was assessed [1,19]. If the patient had an indication for initiating activity out of bed, FM was assessed with the FSS-ICU [12,16]. This scale takes into account 5 items that refers to activities related to mobility: rolling, supine to sit transfer, sitting on the edge of the bed, sit to stand transfer and walking. Each item has a score that ranges from 0 to 7 (see Supplementary material 4 for details). The total score range for the FSS-ICU goes from 0 to 35 points, with higher scores indicating better FM. "Dismobility" is a concept that was used in this study to refer to the difficulty in activities associated with FM. The version of the FSS-ICU used in this study is being validated in Spanish language. MRC SS and FSS-ICU were assessed on awakening and at ICU discharge according to the clinical stability criteria described in Supplementary material 3.

The presence of ICU-AW was defined with a MRC SS <48 points [1] and the presence of ICU delirium with the CAM-ICU [20] (Confusion Assessment Method for the ICU) testing positive at least once a day.

The patient was considered with "Deep Sedation" when the patient presented a Sedation-Agitation Scale (SAS) < 3 points for more than 12 hours a day, and "Absolute Bed Rest" when the patient remained at least one day in bed without even getting into the seated position at the edge of the bed. For analyzing purposes, the "days under deep sedation" was dichotomized in > 3 days and ≤ 3 days [3], the "days on invasive mechanical ventilation" were dichotomized at > 4 days and ≤ 4 days [3] and of "total days with absolute bed rest" was dichotomized into > 6 days and ≤ 6 days [21].

### Statistical analysis

Quantitative variables were reported through medians and interquartile ranges (IQR), and the qualitative variables were reported using absolute and relative frequencies. The variables considered for analysis were: FM (assessed with FSS-ICU), limb strength (assessed with MRC Sum Score), days with absolute bed rest, days on mechanical ventilation, days with ICU delirium, days under deep sedation, among others.

Correlation of the FSS-ICU on awakening with the days under deep sedation was explored. The correlation between FSS-ICU at ICU discharge and days on mechanical ventilation with the presence of ICU delirium and total days with absolute bed rest was explored. In addition, the association between the presence of ICU-AW on awakening and the days under deep sedation was explored. The exploration of correlations was analyzed with rho Spearman and associations with odds ratio. Results are presented through graphs and tables. For the explorations, a confidence level of 95% was taken into account. Data was analyzed using software (StataCorp LLC, Texas USA; <https://www.stata.com/>).

## RESULTS

From the 779 patients admitted at the center on the period covered by the study, 144 met the inclusion criteria. Considering the exclusion criteria and withdrawn, the analyzed sample was 80 patients, as shown in the flow diagram (Figure 1). Baseline

**Table 1:** Baseline characteristics of patients.

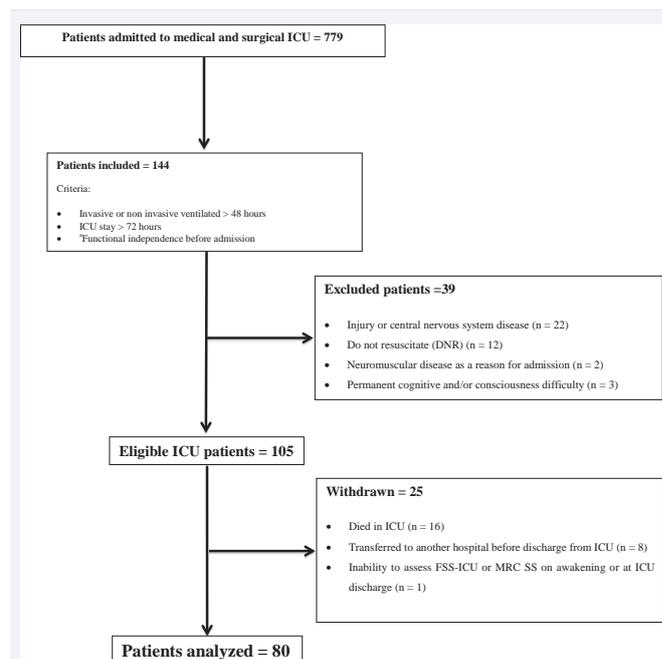
Characteristics	n=80*
Age (years)	54 (25-64.5)
Female	26 (32%)
Body-mass index (kg/m)	28 (24.7-32.5)
Admission diagnosis:	
ARDS	28 (35%)
Sepsis	25 (31.25%)
Cardiac Surgery	6 (7.5%)
Polytrauma	5 (6.25%)
COPD exacerbation	4 (5%)
Other diagnosis	12 (15%)
APACHE II score	20 (14-26.5)
ICU length of stay (days)	13 (9-19.5)
Mechanical ventilation (days)	7 (4-12)
Non invasive ventilation (days)	2 (0-5.5)
ICU delirium (days)	0 (0-3)
Days to first sit on the edge of the bed	7 (4-10)
<sup>a</sup> Absolute bed rest (days)	8 (5-12.5)
<sup>a</sup> Absolute bed rest, % ICU days	61.5%
<sup>b</sup> Deep sedation in ICU (days)	4 (2-7)
<sup>b</sup> Deep sedation, % ICU days	30.7%
Corticosteroids in ICU (days)	7 (0-12.5)
Vasopressor in ICU (days)	2 (0-3)
Number of patients with neuromuscular blocker	16 (20%)
Neuromuscular blocker (hours)	60 (15-108)
Number of patients with renal replacement therapy	11 (13.75%)
Renal replacement therapy (days)	7 (2-9)

\*Values are presented as median (25 - 75% quartiles) or patient number (%).  
<sup>a</sup>Day in which the patient did not even sit on the edge of the bed, but bed mobility was allowed.  
<sup>b</sup>Defined with Sedation-Agitation Scale less than 3 points (1 or 2 points) for more than 12 hours in the day.  
**Abbreviations:** ARDS: Acute Respiratory Distress Syndrome; COPD: Chronic Obstructive Pulmonary Disease; APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU: Intensive Care Unit

**Table 2:** Limb Strength and Functional Mobility in ICU.

Strength and Functional Mobility (n=80)*	ICU Awakening	ICU discharge
MRC Sum Score	44 (35.5-55)	52 (47-58)
ICU-AW <sup>a</sup>	43 (53.75%)	21 (26.25%)
FSS-ICU	17 (10-23)	26 (19.5-32)
Rolling	3 (2-5.5)	6 (4-7)
Supine to Sit Transfer	3 (2-4)	4,5 (3-7)
Sitting at the edge of the bed	5 (3.5-6)	7 (6-7)
Sit to Stand Transfer	3 (2-4)	5 (3,5-7)
Walking	2 (0-4)	4 (3-5,5)
Complete dependence in Walking <sup>b</sup>	36 (45%)	15 (18.8%)

\*Values are presented as median (25 - 75% quartiles) or patient number (%).  
<sup>a</sup>The presence of ICU-AW was defined with a MRC SS <48 points.  
<sup>b</sup>Patient is unable to attempt or complete the task of walking due to weakness or can walk less than 15 meters with the physical assistance of one or two peoples (severe dismobility).  
**Abbreviations:** MRC SS: Medical Research Council Sum Score; FSS-ICU: Functional Status Score for the Intensive Care Unit; ICU-AW: Intensive Care Unit-Acquired Weakness.



**Figure 1** Flow diagram of patients studied

<sup>a</sup>Defined by a score on the Karnofsky Performance Scale > 70%. The functional independence of the last 6 months before admission was determined through a retrospective survey of the patient's legal representative.

Abbreviation: ICU: Intensive Care Unit

The flow diagram shows the inclusion/exclusion criteria and patients who were removed from the study for the reasons mentioned.

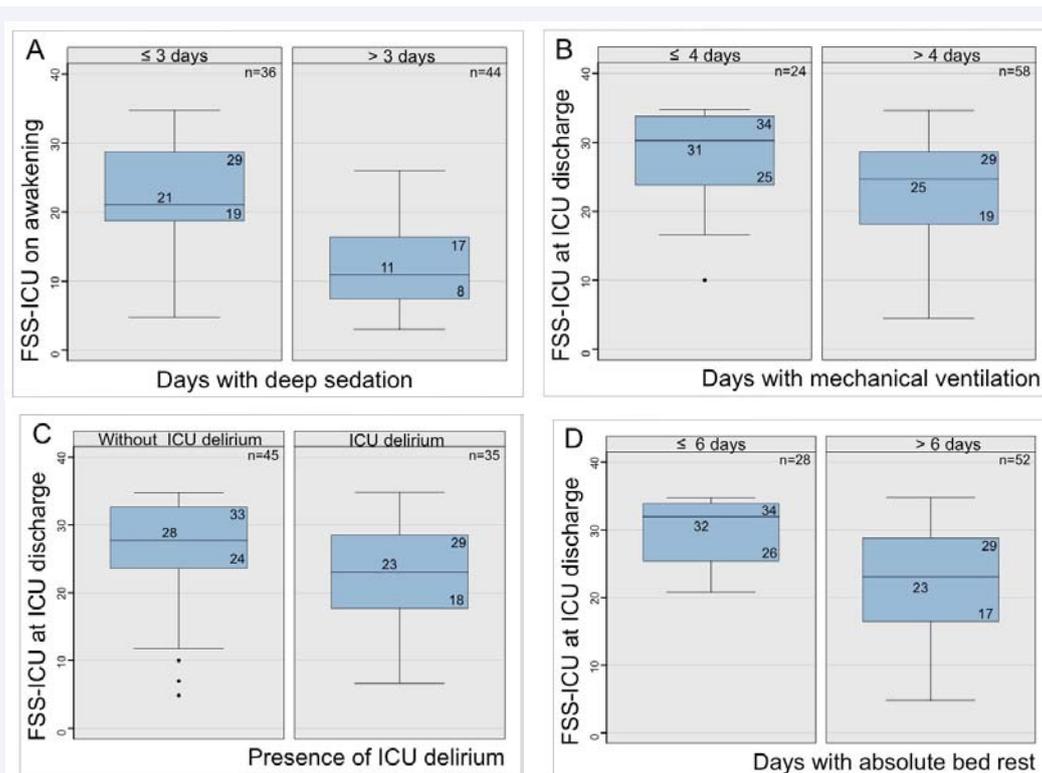
characteristics of patients are described in Table 1. Patients had a median age of 54 years old (IQR 25 - 64.5) and 26 (32%) of them were female. The median APACHE II score was 20 (IQR 14 - 26.50) points. From the 80 patients analyzed, 28 (35%) had an admission diagnosis of acute respiratory distress syndrome (ARDS) and 25 (31.25%) had sepsis. The number of days on IMV was 7 (IQR 4 - 12) that match with the number of days to the first sitting edge of the bed in ICU.

The results for the assessment of FM and strength are described in Table 2. The 53.75% of patients on awakening presented ICU-AW while at ICU discharge it was only 26.25%. Regarding the walking item on awakening, 45% of the patients had < 2 points on FSS-ICU score and only 18.75% scored <2 points when measured at ICU discharge.

The results of the analyses can be seen in Figure (2). The exploration between the FSS-ICU on awakening and deep sedation showed a negative and statistically significant correlation ( $\rho = -0.39$ ;  $p = 0.000$ ). Exploration between the FSS-ICU at ICU discharge and days on invasive mechanical ventilation showed a negative and statistically significant correlation ( $\rho = -0.36$ ;  $p = 0.001$ ), as well with the presence of ICU delirium ( $\rho = -0.25$ ;  $p = 0.027$ ) and total days with absolute bed rest ( $\rho = -0.31$ ,  $p = 0.005$ ). On exploring, the presence of ICU-AW on awakening with the number of days under deep sedation, there was a statistically significant association (odds ratio = 0.1 [95% CI 0.035 to 0.275]).

## DISCUSSION

Active mobilization and rehabilitation in ICU improved body



**Figure 2** FSS-ICU and other conditions

Box plots represent medians (line within box) and interquartile ranges (boxes).

A. This box plot shows the correlation between FSS-ICU on awakening and days under deep sedation. More than 3 days under deep sedation shows a median 11 (8-17) points of FSS-ICU, while 3 days or less of deep sedation shows a median 21 (19-29) points of FSS-ICU.

B. This box plot shows the correlation between FSS-ICU at ICU discharge and days with mechanical ventilation. More than 4 days with mechanical ventilation in ICU shows a median 25 (19-29) points of FSS-ICU, while 4 days or less with mechanical ventilation shows a median 31 (25-34) points of FSS-ICU.

C. This box plot shows the correlation between FSS-ICU at ICU discharge and presence of ICU delirium. Patients with ICU delirium show a median 23 (18-29) points of FSS-ICU, while a patient without ICU delirium shows a median 28 (24-33) points of FSS-ICU.

D. This box plot shows the correlation between FSS-ICU at ICU discharge and total number of days with absolute bed rest. More than 6 days with absolute bed rest in ICU shows a median 23 (17-29) points of FSS-ICU, while 6 days or less of with absolute bed rest shows a median 32 (26-34) points of FSS-ICU.

Abbreviation: FSS-ICU: Functional Status Score for the Intensive Care Unit; ICU: intensive care unit.

function, functional activity and social participation [22]. The selection of an appropriate measuring instruments to identify changes in physical functioning is paramount [5]. This study aims to describe the changes in FM of critically ill patients through the FSS-ICU. There are coincidences with other studies that have used the FSS-ICU [23,24] that had shown changes in FM from awakening to ICU discharge. However, there are differences to published literature. For example in 2010, Zanni et al. [12], had an increase in the median score of the FSS-ICU of 4 points from awakening to ICU discharge (10/35 to 14/35, respectively), whereas in the present study the difference was 9 points (17/35 to 26/35, respectively). There are external factors that influence changes in the FM, such as the type of patients, the differences in the criteria for ICU discharge and the priorities of the center.

Some authors have shown that the minimal important difference in the FSS-ICU, both on awakening and on ICU discharge, goes from 2 to 5 points of the total score, with a minimum floor and ceiling effect (between 0% and 3%) [13,16]. It is also disclosed that the highest scores of the FSS-ICU in ICU are predictive of direct home discharge, without requiring special

care or institutionalization after discharge [13,16,25]. The results from these studies suggest that the differences in FM that arose in the current explorations have clinical relevance.

Others factors that determine worse outcomes in physical functioning and which have been considered barriers to FM are: deep sedation, absolute bed rest, mechanical ventilation and ICU delirium [3,26]. Thus, the variables that were explored in this study regarding FM and ICU-AW were selected based on the evidence, and bear relation to the ABCDE bundle intervention strategy [27]. This multi-professional strategy emphasizes optimizing team work in the ICU, standardization of care processes, priority in reducing sedation, facilitation of early mobilization and extubation [28]. The variables measured in this study represent the problems associated with each of the interventions that make up the ABCDE bundle: days under deep sedation (Awakening), days on mechanical ventilation (Breathing Coordination), presence of ICU delirium (Delirium monitoring/management) and days with absolute bed rest (Early exercise/mobility). The aim was to find out whether these variables determined by the literature are of clinical use in the study center's population, and they are discussed below.

## Days under deep sedation

Recent evidence has led to limiting the use of deep sedation as part of routine management of patients on mechanical ventilation to anticipate patient's awakening time [29]. In this research the proportion of the days under deep sedation in relation to total days in ICU was 30.7%, while in a prospective study from Fan et al, it was 29% [30]. However, this study shows that patients with more than 3 days under deep sedation demonstrate a significant decrease in FM on awakening when compared to those who were deeply sedated  $\leq 3$  days (Figure 2A). This difference seems important to keep in mind for further analysis, since several studies have associated deep sedation with complications related to mobility, longer hospital stays, delirium, increased mortality, prolonged mechanical ventilation, as well as long-term cognitive and depressive symptoms [3,31].

## Days on mechanical ventilation

The international current strategy seeks to reduce the days on mechanical ventilation in order to minimize associated complications [27]. The explorations of this study describe those patients who spend more than 4 days on mechanical ventilation in the ICU showed decreased FM at ICU discharge, in contrast to those who were on mechanical ventilation less than 4 days (Figure 2B).

## ICU delirium

In this study, the incidence of delirium was 44%, with duration from one to three days. The detected delirium was not described based on its hypoactive, hyperactive and mixed phenotypes. The prevalence of ICU delirium described in other studies is 16 to 80%, with higher incidence in patients presenting septic shock and invasive mechanical ventilation [27].

It was determined in this study that there is a statistically significant correlation between the presence of ICU delirium and decreased FM at ICU discharge (Figure 2C).

Delirium has a negative impact on the functional status of patients hospitalized in medical and surgical ICU [27,32], which is associated with physical disability after hospital discharge.

## Days with absolute bed rest

Bed rest has a proven correlation with the loss of muscle mass and of other functions (cardiovascular, energy metabolism, respiratory functions, others) that negatively impact the performance of FM [3]. That is why it is recommended to have indicators that avoid the presence of immobilized patients without explicit medical order [33].

This study considered the amount of absolute days without out of bed activity for patients in the ICU, unlike other studies showing the number of days until the first activities are performed out of bed [sitting edge of bed] [12] or some other functional milestone [standing or walking] [34]. Although there should be similarity, the variable used in this study more fully represents the total number of days without getting up in the ICU, making it a more suitable indicator for comparison between different centers.

In the current study sample, patients with more than 6 days

with absolute bed rest during hospitalization showed a clinically significant decrease in FM at ICU discharge (Figure 2D), compared with patients with more than 6 days with absolute bed rest. The variable "Absolute bed rest" requires further analysis due to the potential benefit that could mean to early and more frequent out of bed activity in critically ill patients.

## Functional mobility/dismobility

Based on the scale proposed by the ICF [7], dismobility was determined as the presence of severe difficulty [0 and 1 point in the FSS-ICU-walking score]. Taking this into account, 19% of patients of this sample were discharged from ICU with severe walking dismobility. This means that patients cannot attempt or complete the task of walking due to weakness or can walk less than 15 meters with the physical assistance of one or two peoples. This is important to emphasize because the quality of walking is described as a predictor of mortality and morbidity [35,36]. Early mobilization has been shown to cause a greater probability of walking without assistance at hospital discharge [22].

Besides, FM involves the synergistic interaction between many functions/structures, such as pain, muscle functions, respiratory functions, balance, motivation, exercise tolerance, etc[11]. Therefore, there is still a knowledge gap separating these functions with the concept of dismobility.

## Relevance and clinical utility

To systematically assess the ICU functional activities as part of the care process, and how it improves the quality of care, this study used the FSS-ICU instrument.

The FSS-ICU was feasible and easy to apply, both on awakening and at discharge, since the 5 assessed activities are performed routinely in the context of the ICU, as described in other studies [13].

The importance of this study is that it generates an objective knowledge basis on FM, being the first study of this kind in Chile. The KPS, s5Q, CAM-ICU, MRC SS and FSS-ICU are used as an assessment battery. These instruments generate clinically relevant adherence and are still used as part of the daily practice by physiotherapist of the ICU. There is a tendency to assess more than just mortality as a clinical outcome in the ICU, but also aspects associated with FM that could have an impact on physical functioning, well being and quality of life of the post-discharge patient [37].

## LIMITATIONS

There are several potential limitations in this present work. First the sample was taken from only two critically ill patient units for the same center, which may limit the accuracy and generalization of these results. Second, due to the observational design of this report, the causal effect for weakness and dismobility cannot be assessed. Finally, there are currently no validated scales available in Chile to assess FM in the ICU. Therefore, in this work the version of the FSS-ICU available at [www.improvelto.com](http://www.improvelto.com) was used.

## CONCLUSION

In conclusion, approximately one in four patients had ICU-AW

and one in five patients had complete dependence to walking at ICU discharge. In addition, an improvement in FM for patients was documented from awakening to ICU discharge. The present study underlines the negative effect of deep sedation with absolute bed rest. Future studies should provide more information about the quality of walking and FM within the ICU and its consequences.

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## CONFLICT OF INTEREST

This work was performed on *Centro de Paciente Crítico Adulto Clínica INDISA*, Santiago, Chile and the authors have not disclosed any potential conflicts of interest.

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