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ORIGINAL ARTICLE

Muscle weakness in critically ill patients: Effects of a systematized rehabilitation nursing program

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KEYWORDS
Rehabilitation nursing;
Muscle weakness;
Functional recovery

Abstract
Objective: Intensive care unit-acquired muscle weakness (ICUAW) in critically ill patients is frequent and associated with negative outcomes. Early rehabilitation is a strategy to improve outcomes. The aim was to assess the effects of a rehabilitation nursing programme at discharge from intensive care unit.
Methods: Quasi-experimental study with the comparison between two groups: one enrolled in a systematized nursing rehabilitation program and the other with usual nursing rehabilitation care. A non-probabilistic sample, sequential, of 42 critically ill ventilated patients, 21 patients in the control group and 21 patients the intervention group (June 2017 to June 2019), in three intensive care units of one large Portuguese teaching hospital. Mann-Whitney test was performed to compare Medical Research Council Sum Score (MRC-SS) values between groups.
Results: Patients undergoing the rehabilitation program had a decrease in ICUAW (at ICU discharge mean MRC-SS = 38 vs. mean MRC-SS = 42.7, p = 0.043, U = 152,5). There was a decrease in severe muscle weakness (9.5% vs. 28.6%) and significant muscle weakness (42.9% vs. 52.4%) and an increase without muscle weakness (47,6% vs. 19%).
Conclusions: The systematic rehabilitation nursing program can improve muscle strength and reduce functional disability at the time of discharge from intensive care.

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PALABRAS CLAVE
Enfermería de rehabilitación;
Debilidad muscular;
Recuperación funcional

Debilidad muscular en pacientes críticamente enfermos: efectos de un Programa de Rehabilitación Sistematizado de Enfermería

Resumen
Objetivo: La debilidad adquirida en la unidad de cuidados intensivos (DAUCI) en pacientes críticos es frecuente y se asocia a resultados negativos. La rehabilitación es una estrategia para mejorar los resultados. El propósito fue evaluar los efectos de un programa de enfermería de rehabilitación al alta de la unidad de cuidados intensivos.
Métodos: Estudio cuasi-experimental. Comparación entre pacientes que se sometieron a cuidados habituales de rehabilitación de enfermería con pacientes que se sometieron a un programa de enfermería de rehabilitación sistematizado. Una muestra no probabilística, secuencial de 42 pacientes críticos ventilados, 21 pacientes en el grupo de control y 21 pacientes en el grupo de intervención (de junio 2017 a junio 2019), en tres unidades de cuidados intensivos de un gran hospital universitario portugués. Se realizó la prueba de Mann-Whitney para comparar los valores de la puntuación total del Medical Research Council Sum Score (MRC-SS) entre los grupos.
Resultados: Los pacientes sometidos al programa de rehabilitación sistematizado, presentaran una disminución de la DAUCI (en el momento del alta de la UCI media de MRC-SS = 38 vs. media de MRC-SS = 42.7, p = 0.043, U = 152,5). Hubo una disminución de la debilidad muscular severa (9,5% vs 28,6%) y debilidad muscular significativo (42,9% vs 52,4%) y aumento de pacientes sin debilidad muscular (47,6% vs 19%).
Conclusiones: El programa de enfermería de rehabilitación sistemática puede mejorar la fuerza muscular y reducir la incapacidad funcional al momento del alta de cuidados intensivos.

What is known

ICU acquired weakness is a complication of critical illness with great impact in strength, physical function and quality of life.

Weakness persisting at ICU discharge is associated with post IUC mortality.

Early rehabilitation can lead to improvements in physical-related outcomes.

What is contributes

Rehabilitation nurse specialist can lead the implementation of rehabilitation programs in the ICU setting.

The systematized nursing rehabilitation program was applicated by rehabilitation nurse specialists, placed full time in the clinical setting.

This study found that the rehabilitation program, applied by rehabilitation nurses can modify the outcomes of ICU-acquired weakness.

Introduction

Although admission to intensive care unit is essential to save lives in critically ill patients, such admission may result in several sequelae such as intensive care unit-acquired muscle weakness (ICUAW). ICUAW consists in an acute neuromuscular impairment and has a significant impact on patients' outcomes, such as prolonged ventilatory weaning, increased length of stay in intensive care and hospital, increased mortality, and persistent weakness with reduced quality of life.[1]

It is estimated that ICUAW may have an incidence of 40% when heterogeneous patient populations are studied,[1] with evidence of the prevalence of muscle weakness six months after discharge,[2] which have a considerable impact on the trajectory of recovery.

Today, a paradigm shift in the provision of care to critically ill patients is advocated, which, according to Vincent,[3] seeks to limit the long-term consequences, even during hospitalization in intensive care. Therefore, it is intended to implement interventions capable of preventing or mitigating the development of ICUAW, with early mobilization being one of the recommended interventions.[4]

As we verified in a previous study,[5] at the time of discharge from intensive care, several patients had high levels of functional dependence in basic self-care and mobility/transfers, having simultaneously developed ICUAW. A study carried out in several intensive care units[6] reported that more than 50% of the patients studied had ICUAW at the time of discharge. This condition was also associated with decreased functionality six months after discharge from intensive care[7] and is significantly related to gait dependence at the time of hospital discharge,[8] a condition that other authors[2] found to remain after six months after discharge from intensive care. Several risk factors are mentioned in the literature,[9] the most associated with the prevalence of this condition upon discharge being immobility.[10]

From the patients' point of view, recovery from ICUAW appears to be a complex process. It begins with exploration and adaptation to a new body, followed by a period of autonomy recovery, where rehabilitation plays a key role, helping to rebuild the future.[11]

The rehabilitation of critically ill patients in intensive care has been debated, with several developments achieved. However, there is still a need to improve the understanding of the results arising from the application of rehabilitation programs, namely regarding the details of the programs and the contexts in which they are introduced.[12]

Previous studies showed the effectiveness of early rehabilitation interventions on outcomes of critically ill mechanically ventilated patients, namely on muscle strength. However, a systematic review with meta-analysis concluded that, despite decreasing the incidence of ICUAW at hospital discharge, early rehabilitation had no effect on Medical Research Council Sum Score (MRC-SS) at Intensive Care Unit (ICU) discharge.[13] Another recent systematic review with meta-analysis also concluded that the evidence regarding the benefit of early systematized rehabilitation remains inconclusive, with no statistically significant difference being found in the MRC-SS at ICU discharge.[14] MRC-SS values are a measure of peripheral limb muscle strength and for the diagnosis of ICUAW. The initial assessment and in the ICU discharge, allows to verify if there have been gains in muscle strength.

In a previous study[15] a nursing rehabilitation program was developed, implemented, and tested and its effects were analyzed. Differentially from other nursing rehabilitation interventions, this program was developed and applied entirely by specialist rehabilitation nurses', exclusively dedicated to the critically ill patient's rehabilitation.

The objective of this study was to analyze the effects of this rehabilitation program on the muscular strength of critically ill mechanically ventilated patients at ICU discharge.

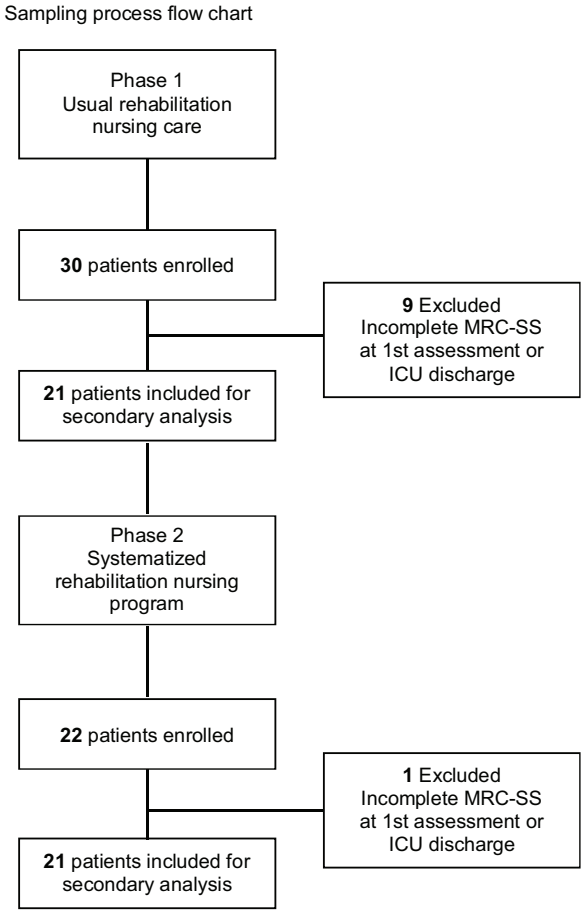
Methods

A secondary analysis of data obtained during a study[15] was carried out. Data obtained from a quasi-experimental study, with a pre-test/post-test design, with a non-equivalent control group, longitudinal, with two cohorts and two phases. In phase one, patients received usual rehabilitation nursing care in the services five days a week. There were no rehabilitation protocols in the services. Functional respiratory and motor rehabilitation care was performed, from bed exercises to transfer to a chair, with no walking exercises in patients placed on IMV. In the second phase, the rehabilitation nursing care was provided following a systematized rehabilitation nursing program (Fig. 1).

During the first phase, nurses were unaware of the rehabilitation program, which was only presented and explained immediately before phase two. Local medical indications for treating critically ill patients were followed, in both groups, regarding sedation, mechanical ventilation, antibiotic therapy, nutritional support, and the use of steroids.

Patients were selected with an expected stay in intensive care for more than seven days, placed on invasive mechanical ventilation, aged 18 years or over, and able to understand written and spoken Portuguese. Exclusion criteria were: cardiovascular instability, respiratory instability, unstable spinal injury, unstable fractures, neurological deterioration, deep vein thrombosis and post-cardiac arrest. Baseline demographics and clinical characteristics (reasons for admission) were collected at study enrolment in both phases.

The sampling was non-probabilistic and sequential and the selection process took place according to the following flow chart:



Data from 42 patients of three medical/surgical intensive care units of one large teaching hospital in Oporto, Portugal, were analyzed: 21 in phase one and 21 in phase two, comparing the results obtained in the two phases.

For this analysis, the results regarding days of ICU stay, days of sedation, days on Invasive Mechanical Ventilation (IMV) and use of corticosteroids were considered and the primary outcomes were MRC-SS values. With MRC-SS, six peripheric muscle groups are assessed bilaterally (shoulder abductors, elbow flexors, wrist extensors, hip flexors, knee flexors and foot dorsiflexors), scoring from 0 to 5 according to the muscle strength and then individual scores are combined into a sum score that ranges from 0 (complete paralysis) to 60 (normal strength). Cutoff values already used in other studies were adopted,10 having as a reference that a value lower than 48 points makes the diagnosis of ICUAW.

Data were collected by the rehabilitation nurses of the services in forms created specifically for the study, between June, 2017 and June, 2019. In both phases' values of MRC-SS were obtained, at the time patients woke up from sedation and were in conditions to perform the test (follow three

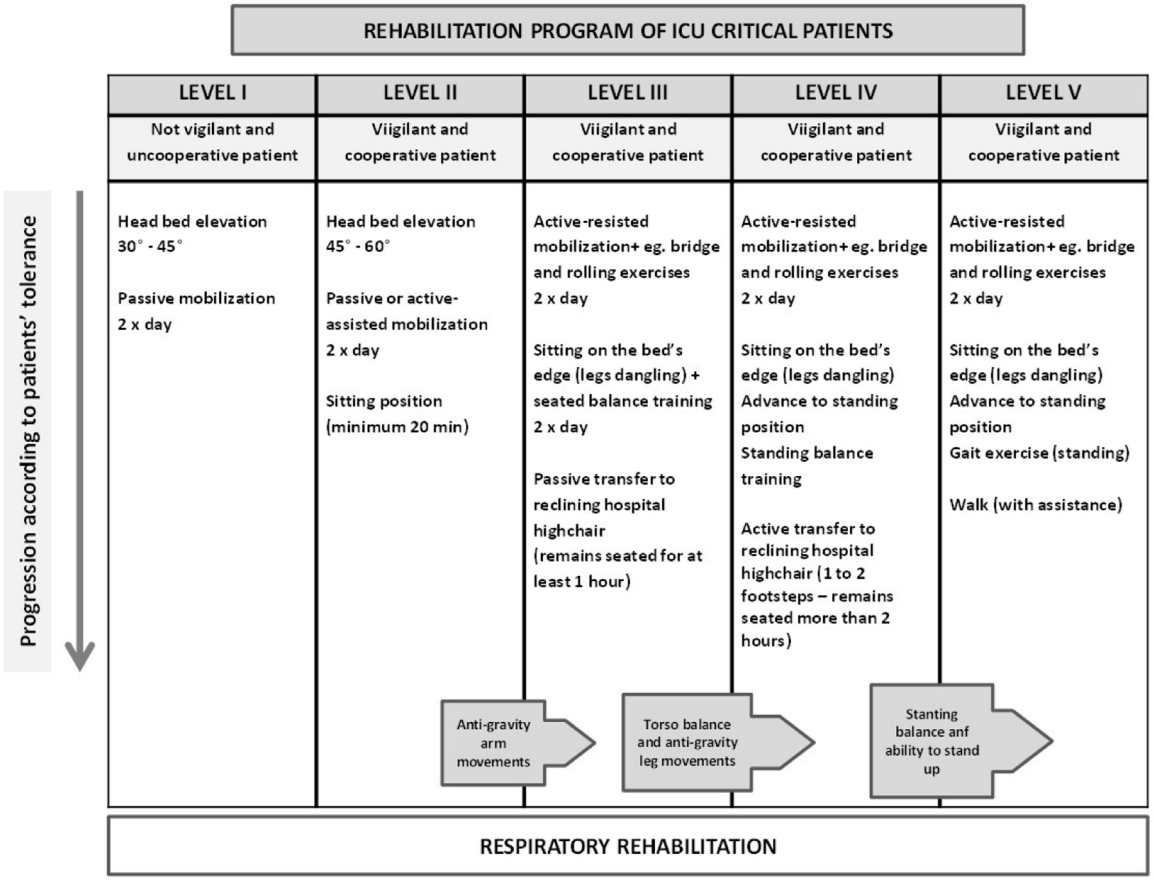


Figure 1 Systematized Rehabilitation Nursing Program (Azevedo, 2020).

out of four commands) and at the time of discharge from intensive care.

Statistical tests were performed to compare the MRC-SS values in each phase with the R system for statistical computation, version 4.1.2. software. The Mann-Whitney test (independent samples) was used to compare the MRC-SS at the two moments in each phase and to characterize the degree of muscle strength.

Ethical procedures were adopted to develop the study regarding the anonymization of data and authorization of patients, or next of kin, for participation, with participants being able to leave the study at any time, without any consequences. Phase two patients, or next of kin, were given verbal and written explanations of the rehabilitation program and its implications. The study has been approved by the local ethics committee (CES 24/4/2017) and authorization was obtained from the boards of directors, heads of services and the research unit. Rehabilitation nurses agreed to participate in the study.

The results related to the program's application safety, other results, and particularities of its application, have been previously published.[15]

Results

Results from 42 patients, 21 in phase one and 21 in phase two, of descriptive statistics, are presented as mean, standard deviation, and absolute and relative frequencies in percentage.

The reasons for admission to the intensive care unit (Table 1) were heterogeneous in both phases.

Distribution by sex shows a predominance of males in both phases, phase one (61,9% vs 38,1%) and phase two (57,1% vs 42,9%). Despite, in phase two, the difference between males and females was not marked.

On average, patients in phase one were older, with a higher standard deviation in this phase. Patients in phase two, on average, had more days of hospitalization, sedation, and IMV (Table 2).

A higher percentage (66% vs. 38%) of patients using corticosteroids was found in phase two.

To compare mean values of MRC-SS, independent samples (non-normal distribution by Shapiro-Wilk test) we used the Mann-Withney test (Table 3). In the first assessment in each phase, given the values obtained it is assumed that the mean value is the same in the two phases. For the MRC-SS values at ICU discharge in each phase, for the values obtained it is concluded that the mean value in phase one is lower than that of phase two patients.

Regarding the variation in the MRC-SS in phase one, in patients who received usual rehabilitation nursing care, between the first assessment and discharge from intensive care, there was a decrease in patients with severe muscle weakness, with an increase in those with significant muscle weakness. At discharge, 19% of patients had no muscle weak-

Table 1 Reason for admission to Intensive Care.

Reason for admission Phase 1		Reason for admission Phase 2	
After cardiorespiratory arrest	1	Subdural hemorrhage	1
Respiratory failure	3	Drug intoxication	1
Subdural hematoma	1	Polytraumatized	5
Septic shock	2	Heatstroke	1
Sepsis	2	Subarachnoid hemorrhage	1
Brain hemorrhage	1	Brain hemorrhage	1
ALI / ARDS	1	TBI	1
Postoperative exeresis of nose carcinoma	1	CAP	3
Ischemic Stroke	1	Alveolar hemorrhage	1
Subarachnoid hemorrhage	1	Pneumonia	2
TBI	1	Mediastinitis	1
Gillian Barré	1	Respiratory failure	1
Miasteneia Gravis	2	Cardiogenic shock	1
Status epilepticus	1		
Distributive shock	1		
Acute Pancreatitis	1		
Total	**21**		**21**

TBI – traumatic brain injury.
ALI/ARDS – Acute Lung Injury / Acute Respiratory Distress Syndrome.
CAP – Community-Acquired Pneumonia.

ness. Regarding the variation in the MRC-SS score in phase two, in patients who received rehabilitation nursing care following the systematic rehabilitation program, between the first assessment and discharge from intensive care, there was a decrease in patients with severe muscle weakness, with an increase in those with significant muscle weakness. At discharge, 47.6% of patients had no muscle weakness (Table 4).

In both phases, a significant percentage of patients was discharged with a diagnosis of ICUAW (81% in phase 1 and 52.4% in phase 2).

The program compliance rate was 61.7% (333/539 interventions), with the mean exposure time to the program being 10.2 days. However, the exposure time was less than ten days for 13 patients (62%).

Table 2 Patients profile.

	Phase 1	Phase 2
Minimum age	25	21
Maximum age	82	69
Mean age	57,2	48,6
Standard deviation	15,7	13,6
Mean days in ICU	20,1	25,2
Standard deviation	12,7	0
Mean days of sedation	8,9	16,4*
Standard deviation	9,3	8,5
Mean days of IMV	13,2	20**
Standard deviation	11	19,7

* Data lost from two patients in phase 2 / ** data lost from one patient in phase 2.
ICU – Intensive Care Unit / IMV – Invasive Mechanical Ventilation.

Discussion

The development of ICUAW has several negative repercussions on patients' health conditions and until now an efficient therapeutic approach to this problem has not been available. A recent study[16] has failed to find a pharmacological therapy to increase diaphragm and quadriceps muscle strength in patients with ICUAW, confirming that the muscle strength of the diaphragm and quadriceps in these patients is profoundly reduced. Therefore, the strategies remain centered on prevention, emphasizing specific risk factors and on non-pharmacological strategies like rehabilitation programs.

This study compared the evolution of muscle strength in patients admitted to intensive care, placed on IMV and who received rehabilitation nursing care during ICU stay. In patients included in phase two of the study, a systematic rehabilitation nursing program was applied, recommending the increase in frequency (number of sessions/day) and intensity (needed energy to perform the activity and strength).

Improved muscle strength gains were observed in phase two patients, which underwent the systematic rehabilitation nursing program. These results are evidenced by the decrease in patients with some degree of muscle weakness and patients without muscle weakness. There was a significant decrease in patients who, in phase two at discharge, had severe muscle weakness (9.5% vs. 28.6%) and significant muscle weakness (42.9% vs. 52.4%); this difference was higher in patients who were discharged with no muscle weakness (47% vs 19%).

It was also found that comparing the evolution of gains in muscle strength between the first assessment and at discharge results was better in patients on the rehabilitation program. In phase two of the study, between the first assessment and discharge, there was a decrease in 52.5% of patients with severe muscle weakness, a decrease in 9.6% of

Table 3 Medical Research Council Sum Score Values.

	First assessment			ICU discharge		
	Phase 1	Phase 2	Total	Phase 1	Phase 2	Total
MRC-SS min.	0	0	0	8	27	8
MRC-SS máx.	48	48	48	60	48	60
Mean	27	30	28.3	38	42.7	40.3
Mann-Whitney U	281			152.5		
p-value	0.800			0.043		

MRC-SS min. – Medical Research Council Sum Score minimum value.
MRC-SS máx. – Medical Research Council Sum Score maximum value.

Table 4 Variation of MRC-SS values in phase 1 and phase 2.

	First assessment		Discharge	
	n	%	n	%
Phase 1 Severe ICUAW MRC-SS < 36	14	**66,7**	6	**28,6**
Phase 1 Significant ICUAW MRC-SS 36 - 47	7	**33,3**	11	**52,4**
Phase 1 No muscle ICUAW MRC-SS ≥ 48	0	**0**	4	**19**
Total Phase 1	21	100	21	100
Phase 2 Severe ICUAW MRC-SS < 36	13	**62**	2	**9,5**
Phase 2 Significant ICUAW MRC-SS 36 - 47	7	**33,3**	9	**42,9**
Phase 2 No ICUAW MRC-SS ≥ 48	1	**4,7**	10	**47,6**
Total Phase 2	21	100	21	100

ICUAW – Intensive Care Unit Acquired Weakness.
MRC-SS – Medical Research Council Sum Score.

patients with significant muscle weakness, and an increase in 42.9% of patients without muscle weakness, whereas, in phase one, between the first assessment and discharge, there was a 38.1% decrease in patients with severe muscle weakness, an increase in 19% in patients with significant muscle weakness and a 19% increase in patients with no muscle weakness.

These results are in line with some authors that report a beneficial effect of rehabilitation. In a systematic review, Tipping,[17] reported that active mobilization of patients hospitalized in intensive care could improve mobility and muscle strength. Verceles,[18] in a study where a multimodal rehabilitation program that associated muscle training and endurance training to usual care, found an improvement in muscle strength, compared with patients undergoing usual care. Winkelman,[19] found increased muscle strength in patients undergoing early mobilization with an intensity greater than usual care.

However, other authors reported different results from those obtained in this study. Eggmann,[20] verified a decrease of ICUAW in patients discharged from ICU in the group submitted to mobilization with combined endurance and resistance exercises, but showed no statistically significant difference in MRC-SS at ICU discharge, in line with previous results of Kayambu[21] and Hodgson.[22] It should be noted, however, that in these studies, only the MRC-SS at ICU discharge was reported and no comparison was made with the patient's initial score, therefore, no conclusions can be drawn regarding the evolution of gains in muscle strength during the ICU stay in the intervention and control groups.

Similar to this study, Dantas,[23] performed a comparison of the values of MRC-SS initially and at discharge and reported a statistically significant higher MRC-SS in favour of the systematic early mobilization group, compared with standard mobilization. However, in that study, the mean MRC-SS of patients in the intervention group was already higher at baseline when compared to the control group. Also in this study, phase two patients had a slightly higher baseline MRC-SS. Thus, the stratification of ICUAW as presented here made it possible to make the benefits in favour of patients undergoing the rehabilitation program more evident.

Factors such as administration of corticosteroids,[24] older age, duration of IMV, and sepsis[25] may contribute to the development of ICUAW. In phase one the group of patients were older and more patients had sepsis. However, in phase two, there were more patients treated with corticosteroids, with a longer duration of IMV and more days of sedation, which increases the risk of immobility and intensive care stay. Thus, patients in both phases had risk factors, but phase two patients had more significant risk factors, which further enhances the results obtained with the application of the rehabilitation program.

It should also be noted that the time during which patients were subject to the program was relatively short so that, in terms of functional recovery, more significant improvements could be observed. Depending on the results obtained, it is suggested the implementation of rehabilitation programs that provide an increase in the intensity and frequency of rehabilitation.

This study has some limitations. A small convenience sample, even if heterogeneous, is not representative of all

patients admitted to the services at a given time. Possible comorbidities before hospitalization, a factor that can affect the recovery of health status and collaboration in rehabilitation, were also not studied.

Despite some limitations, this study has implications for clinical practice in the context of rehabilitation nursing care for critically ill patients. Although rehabilitation nursing care was instituted, there were patients who, at the time of discharge from intensive care, still had high levels of physical disability due to the development of ICAUW, which motivates the need to improve the characterization of these disabilities to plan the continuity of nursing rehabilitation care.

Conclusions

Results suggest that the systematic rehabilitation program, compared with the usual rehabilitation care, can improve gains in muscle strength and reduce the level of functional disability at the time of discharge. To better understand the effects of such a program, it should be applied to a more robust sample of patients and improved application rate.

The findings of this study have implications for rehabilitation nursing specialist interventions, whether during the patient's stay in the intensive care unit and for the continuity of care after transfer to the ward.

Conflict of interest

The authors declare that they have no conflicts of interest.

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