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Clinical Study

Effect of Early Mobilization on Respiratory and Limb Muscle Strength and Functionality of Nonintubated Patients in Critical Care: A Feasibility Trial

Maria Karoline Richtrmoc,[1,2] **Wagner Souza Leite**,[1,2] **Anielle Martins Azevedo**,[1] **Raissa Farias Correia**,[1] **Rômulo de Aquino Coelho Lins**,[1] **Wildberg Alencar Lima**,[2] **Caio César Araújo Morais**,[3] **Rodrigo Rios Pereira**,[2] **Monique Bandeira**,[1] **Carlos Eduardo Santos Rego Barros**,[1] **Amina Maria Soares de Lima**,[1] **Maria Glória Rodrigues-Machado**,[4] **Daniella Cunha Brandão**,[1] **Armèle Dornelas De Andrade**,[1] **Maria Inês Remigio de Aguiar**,[1,2] **and Shirley Lima Campos**[1]

[1]*Department of Physical Therapy, Universidade Federal de Pernambuco, Recife 50670-901, Brazil*
[2]*Department of Physical Therapy, Real Hospital Português de Beneficência em Pernambuco, Recife 52010-075, Brazil*
[3]*Department of Anesthesia, Critical Care and Pain Medicine, Massachusetts General Hospital, Boston, MA, USA*
[4]*Post-Graduation Program in Health Sciences, Faculdade Ciências Médicas de Minas Gerais, Belo Horizonte 30130-110, Brazil*

Correspondence should be addressed to Wagner Souza Leite; wagnerszleite@gmail.com

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Purpose. To assess the potential effectiveness or efficacy of early mobilization on respiratory and peripheral muscle strengths and functionality in nonintubated patients. *Methods*. For 40 nonintubated patients over 18 years of age with over 24-hour intensive care unit (ICU) stay allocated to a single intervention, an incremental mobilization protocol was initiated. Maximal inspiratory and expiratory pressures (MIP and MEP), peripheral muscle strength (handgrip strength (HGS) and Medical Research Council scale (MRC-s)), and functionality (FIM, ICF-BMS, PFIT-s, and FSS-ICU scales) were evaluated at ICU admission and discharge. *Results*. All outcomes were significantly improved (pre vs. post values): MIP (43.93 ± 21.95 vs. 54.12 ± 21.68 cmH2O; $P < 0.001$), MEP (50.32 ± 28.65 vs. 60.30 ± 21.23; $P = 0.002$), HGS (25.5 (9.58) vs. 27.5 (9.48); $P = 0.046$), MRC-s (58.52 ± 2.84 vs. 59.47 ± 1.81; $P = 0.023$), FIM (54.4 ± 22.79 vs. 69.48 ± 12.74), ICF-BMS (28.63 ± 16.19 vs. 14.03 ± 11.15), PFIT-s (9.55 ± 2.34 vs. 11.18 ± 1.32) ($P < 0.001$), and FSS-ICU (28.7 ± 9.1 vs. 32.6 ± 5.0; $P = 0.001$). The ceiling effect at admission/discharge was in MRC-s (60/82.5%), FSS-ICU (50/70%), and FIM (35/62.5%). The floor effect occurred at discharge in ICF-BMS (7.5/52.5%). *Conclusions*. The early mobilization protocol seemed effective at maintaining/increasing the respiratory muscle strength and functionality of non-intubated patients in critical care. Ceiling effect was high for MRC-s, FSS-ICU, and FIM scales.

1. Introduction

In order to prevent deleterious effects, early mobilization protocols have been implemented in patients undergoing invasive ventilatory support and its results also indicate a reduction in mechanical ventilation time and intensive care unit (ICU) and hospitalization length of stay, thereby favoring better functional capacity on a long-term basis and quality of life after discharge [1–4].

Spontaneous-breathing patients who are also exposed to ICU bed rest may suffer the consequences of hypomobility, such as muscle hypotrophy, joint and soft tissue impairment, cardiovascular deconditioning, and low physical performance [5, 6]. It may be even worse when they are subject to

healthcare professionals' subjectivity for exercise prescription after evaluation at ICU admission and hospital stay follow-up [7].

The beneficial effects of early mobilization in patients under mechanical ventilation such as reducing the adverse effects of immobility, improving respiratory function, cardiovascular conditioning, level of consciousness, functional independence, and psychological well-being have been reported in systematic reviews [8–11]; however, its effect in spontaneous-breathing patients requiring critical care remains scarce [12]. Thus, the effects of an early mobilization program for critical patients spontaneously breathing who were admitted to an ICU presenting cardiorespiratory stability, with neither apparent muscle strength nor functional deficit, are still unknown.

This study aimed to investigate the potential effectiveness or efficacy of early mobilization on respiratory and peripheral muscle strength and functional capacity in non-intubated patients admitted to an ICU. The secondary objectives were to verify the frequency of floor and ceiling effects in scales used for evaluation of peripheral muscle strength and functionality and the safety of the mobilization by reporting the potential resulting adverse events.

2. Materials and Methods

2.1. Study Design. In this feasibility trial, the participants who met the inclusion criteria were provided with an explanation of the one-arm research protocol and invited to give a written informed consent. Their medical conditions were mainly cases of geriatrics, oncology, gynecology, orthopedics, and general surgery.

The experiment was conducted with the human subjects' understanding and consent. The participants were aware of withdrawing from the study at any time with no negative consequences. This experimental study was registered with NCT02919085 and with the approval of the Research on Human Beings Ethical Committee of Universidade Federal de Pernambuco, protocol 1.488.525, respecting the secrecy and confidentiality of data policy. This study was conducted in accordance with the Declaration of Helsinki (1964).

2.2. Participants. All the participants were recruited by consecutive sampling in a critical care setting. All data were collected from an adult ICU of the Real Hospital Português de Beneficência em Pernambuco in Recife, Brazil, from December 2016 to April 2017. The study included spontaneous-breathing patients of both genders, over 18 years old, body mass index (BMI) $< 35\,kg/m^2$, and ICU length of stay over 24 hours, with written informed consent by the patients and/or their companion.

The study excluded patients with any of the following: chronic lung disease; preexisting neuromuscular diseases; immobility or being at bed rest condition before hospitalization; amputations and fractures; previous musculoskeletal, cognitive, or neurological impairment or noncollaboration; or specific contraindications to the evaluation methods [13, 14], thereby hindering assessments of muscle strength and functional capacity in the period up to 48 hours of ICU admission, such as hemodynamic instability (hyper- or hypotension-mean arterial pressure ≥ 110 mmHg and <60 mmHg; high doses of vasoactive drugs (noradrenaline $\geq 1\,\mu g/kg/min$ and/or dopamine $\geq 2\,\mu g/kg/min$ and dobutamine $\geq 5\,\mu g/kg/min$); decompensated heart failure; or arrhythmias with hemodynamic repercussions); and respiratory rate ≥ 35 incursions/minute and peripheral oxygen saturation (SpO_2) $\leq 88\%$. Patients who did not agree to participate in the study were also excluded.

2.3. Outcome Measures. Patients were screened daily by the team involved in the study and those who consented to be part of the study were evaluated by two trained evaluators. Data on the history, current disease status, and general physical examination were collected. Main and secondary outcomes were measured in the hospital at 48 hours of ICU admission (baseline) and on the day of ICU discharge.

2.4. Main Outcomes. Respiratory muscle strength was represented by maximal inspiratory (MIP) and expiratory (MEP) pressures measured using a digital manometer. The procedure, previously explained by the evaluator, was performed with the patient in the supine position in bed with their head elevated at 45°, breathing spontaneously through a mouthpiece and using a nasal clip.

MIP was assessed from the residual volume by examiners who instructed the patients to breathe all the air out and then breathe in deeply through the manometer mouthpiece. MEP was measured from the total lung capacity, in which subjects were instructed to inhale their lungs to the fullest and then to breath out strongly into the device.

Three MIP and MEP maneuvers were performed with an interval of 1 minute of rest between them. No variation $> 10\%$ between the measures was considered satisfactory and the highest value was chosen according to the American Thoracic Society/European Respiratory Society guidelines [15]. Predicted values and lower limits of normality were proposed by Neder et al. [16].

Peripheral muscle strength was represented by the handgrip strength (HGS) using hand-held dynamometry and the Medical Research Council scale (MRC-s). The standard position proposed by the American Society of Hand Therapists [17] was adopted. To compare normal values, the 50th percentile for HGS for both genders was used by age groups as proposed by Schlüssel et al. [18] We also adopted the cut-off points proposed by Ali et al. [13] for a diagnosis of weakness acquired in the ICU, being 7 kgf for women and 11 kgf for men.

Functionality status scales were applied according to the sequence of incremental evolution with a five-minute rest among them. The evaluators were previously trained and instructed on the application of the scales and followed the recommendations of instrument methods and clinical trials of the Core Outcome Measures in Effectiveness Trials (COMET) initiative project [19], which promotes the creation of measuring standards for clinical trials.

The functionality assessment tools used were the Functional Independence Measure (FIM), [20] the Functional Status Score for the Intensive Care Unit (FSS-ICU) [5], the International Classification of Functioning, Disability and Health-Based Basic Mobility Scale (ICF-BMS) [21], and the scored Physical Function Intensive Care Test (PFIT-s) [22]. Only FIM and FSS-ICU are validated for the Brazilian population [23, 24] by the time the study was conducted and ICF-BMS and PFIT-s have already been in use internationally to assess the functionality of people confined to ICU environment [25].

2.5. Secondary Outcomes. Anthropometric, clinical, and laboratorial exam data were recorded at the ICU admission: age, gender, BMI, Simplified Acute Physiology Score III (SAPS III), Sequential Organ Failure Assessment (SOFA), lactate, PaO2/FiO2 ratio, and reasons for hospitalization. The need for oxygen therapy and/or noninvasive ventilation during hospitalization, length of stay in the ICU, and hospitalization were monitored daily by patients' charts until their hospital discharge.

Adverse events reported during ICU stay were registered and defined as follows: hemodynamic instability, respiratory instability, dyspnea sensation, loss of probes and venous accesses, and falls [9].

2.6. Intervention. The protocol was performed on a daily basis seven times a week, and the exercises proposed in each step could be performed two times a day. The protocol for this study started from stage 2, with a consciousness level compatible with 9 points or more on the Glasgow Coma Scale and the intensity adjustment was performed daily according to a routine physical therapy evaluation based on the evolution of the given functional criterion muscle strength of the upper limbs and lower limbs.

In addition to the usual care of the multidisciplinary team, the patients received physiotherapeutic care from the local professionals with respiratory care according to the ICU clinical routine before being submitted to the protocol of incremental early mobilization. In order to maximise the patients' compliance to the protocol, they were constantly encouraged and educated with the intervention benefits for a faster recovery.

The early mobilization protocol of this study was adopted from previous studies [26, 27] and was structured in 5 steps according to the consciousness level and the scope of the functional criterion proposed for each stage. Patients were intended to receive their intervention twice a day as long as they stayed in the ICU. The protocol description for incremental early mobilization is shown in Figure 1.

After initiating the mobilization, some safety criteria were followed in case of needed interruption, such as variation in blood pressure > 20% of the their initial measure; excessive heart rate increase (20 beats above baseline or up to 120 bpm); ectopic heartbeat or presence of arrhythmias; a significant decrease in SpO2 (<90%); and significant anxiety or significant signs of discomfort [7], monitored during activities with the patient near the bed or upon arrival when they are left to wander.

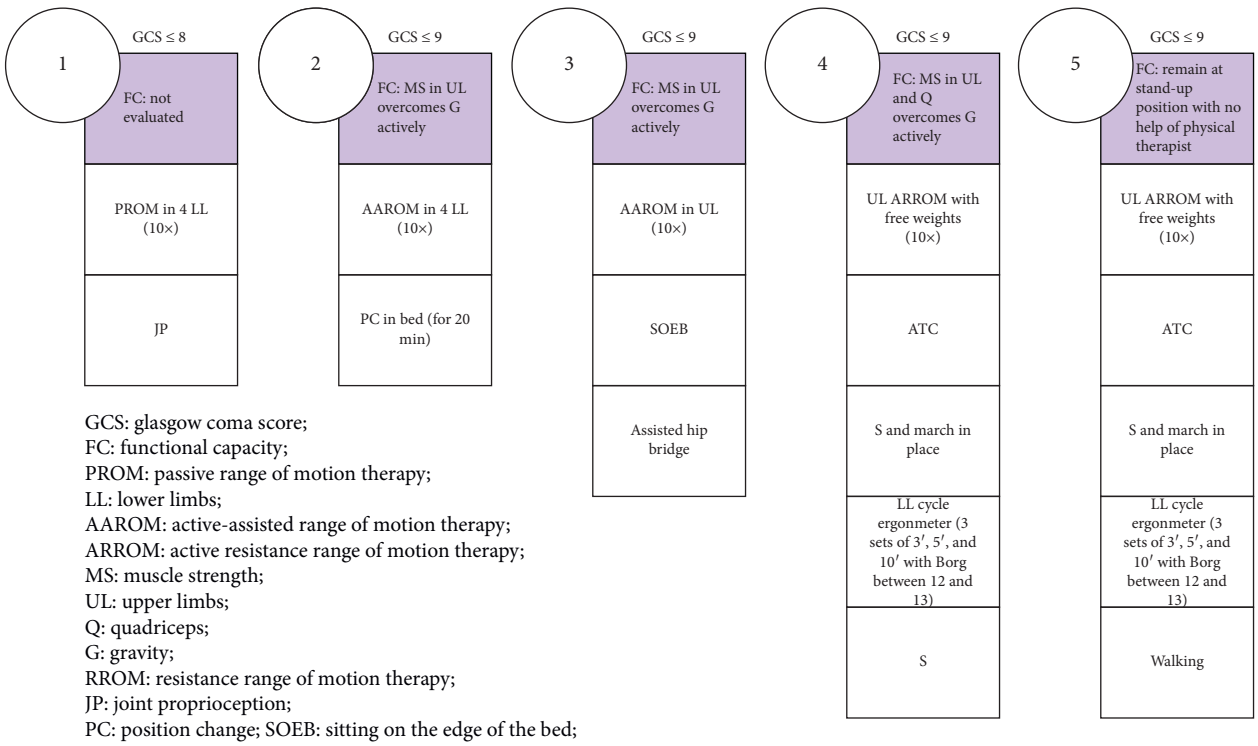
2.7. Statistical Analysis. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 20.0 d. The Kolmogorov–Smirnov test was employed to verify the data normality of distribution. Baseline descriptive data were presented in mean and standard deviation for continuous data and relative frequency for categorical data. Paired Student's t-test for normal distribution and Wilcoxon test for nonnormal distribution were used to determine the significance of time effect (within subjects) on continuous data. Multiple analyses for effect size were also conducted:

(1) Comparison between the primary outcomes at ICU admission and discharge times by means of the t-test for dependent samples or Wilcoxon test with their respective t or Z values, mean or median differences, 95% confidence interval, minimal detectable change (MDC) and the percentage of those patients who achieved the minimally clinically important difference (% of participants who presented the MCID in outcomes), and effect size. MDC and MCID are terms used to define analysis of individual scores. MDC represents a valid change in score that is not due to chance. It ensures the change is not the result of measurement error. It was calculated with the following formula: standard error of measurement (SEM) $\times 1.96 \times \sqrt{2}$ (33). MCID, in comparison, goes beyond valid change. It is a published value of change in an instrument that indicates the minimum amount of change considered important by the patient or a professional. A few instruments deployed in this study have published MCID that we used to support our analysis. Cohen's d was the measure of effect size adopted with the purpose of comparing the relative magnitude of the experimental treatment. It estimated the difference between two means divided by the standard deviation of the two conditions

(2) Proportion test of individuals who presented positive (maintenance or increment) and negative (reduction/loss) effects on outcomes at ICU discharge was performed with the binomial test with test proportion of 0.5. No t or Z statistic test values can be provided in this binomial analysis

(3) Analysis of floor and ceiling effects for the MRC-s scales and functionality at admission and discharge points by calculating the number of people that reached the maximum or minimum score divided by the total number of patients was represented in relative frequency and range. No t or Z statistic test values can be provided in this analysis.

The level of significance level was set at $P < 0.05$. Mean and standard deviation and mean differences with 95% confidence intervals were reported.



GCS: glasgow coma score;
FC: functional capacity;
PROM: passive range of motion therapy;
LL: lower limbs;
AAROM: active-assisted range of motion therapy;
ARROM: active resistance range of motion therapy;
MS: muscle strength;
UL: upper limbs;
Q: quadriceps;
G: gravity;
RROM: resistance range of motion therapy;
JP: joint proprioception;
PC: position change; SOEB: sitting on the edge of the bed;
ATC: active transfer to chair;
S: standing-up;
BORG: Borg scale of perceived exertion
Note: Mobilzation protocol adopted by Real Hospital Portugues, 2016-2017.

Figure 1: Early mobilization protocol.

2.8. Sample Size Calculation. A pilot trial was carried out with the first ten patients enrolled in the research study, and the sample size was calculated using the G∗Power 3.1.3[a] computer program. We used mean and standard deviation between two paired samples for the outcomes maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), handgrip strength (HGS), and Physical Function ICU Test Score (PFIT-s), with $\alpha = 0.05$ and $\beta = 0.80$. The PFIT-s result pointed to the largest sample size of 40 patients with an effect size of 0.45, being set as the number of participants for this study.

3. Results

One hundred ninety-nine (199) out of the 243 patients admitted to the ICU during the study period met the inclusion criteria, of which 159 were excluded, mainly due to cognitive or neurological impairment or hospitalization length of stay <24 hours, or impossibility of evaluation in the first 48 hours of ICU admission. A total of 40 patients participated in the study with no occurrence of losses for data analysis (Figure 2). All the patients collaborated with the number of sessions intended after their clinical stability was checked to proceed safely.

Table 1 describes the participants' characterization, length of hospital stay, and the absence of adverse effects to the implementation of the incremental early mobilization protocol proposed for this study.

Based on the predicted values of normality proposed by Neder et al. [16], 92.5% of the patients presented reductions in MIP and 87.5% in MEP at admission. After patients were submitted to the intervention protocol, all their outcomes showed significant improvement: MIP (10.2, 5.78 to 14.61; $P < 0.001$), FIM (15.08, 9.03 to 21.12; $P < 0.001$), ICF-BMS (−14.6, −19.18 to −10.02; $P < 0.001$), PFIT-s (1.63, 0.91 to 2.34; $P < 0.001$), FSS-ICU (3.9, 1.75 to 6.05; $P = 0.001$), and MEP (10, 4 to 16; $P = 0.002$). We found an average increase in MIP by 10.2 cmH2O and in MEP by 10 cmH2O at discharge from the ICU (Table 2).

Peripheral muscle strength measured by the MRC-s (0.95, 0.01 to 1.89; $P = 0.02$) and HGS (2, −0.1 to 3.5; $P = 0.046$) had a significant statistical improvement with a lower magnitude, however with no minimal detectable change. Therefore, the improvement measured for peripheral muscle strength does not have any clinical relevance (Table 2).

The MDC provides an estimate of the smallest detectable difference that might be considered to be true change rather than measurement error. Therefore, comparing the mean or median difference between admission and discharge to the MDC values estimated, the respiratory muscles pressures did suffer a true change (MIP and MEP values) as well as the functionality scales, FIM, ICF-BMS, and PFIT-s (Table 2).

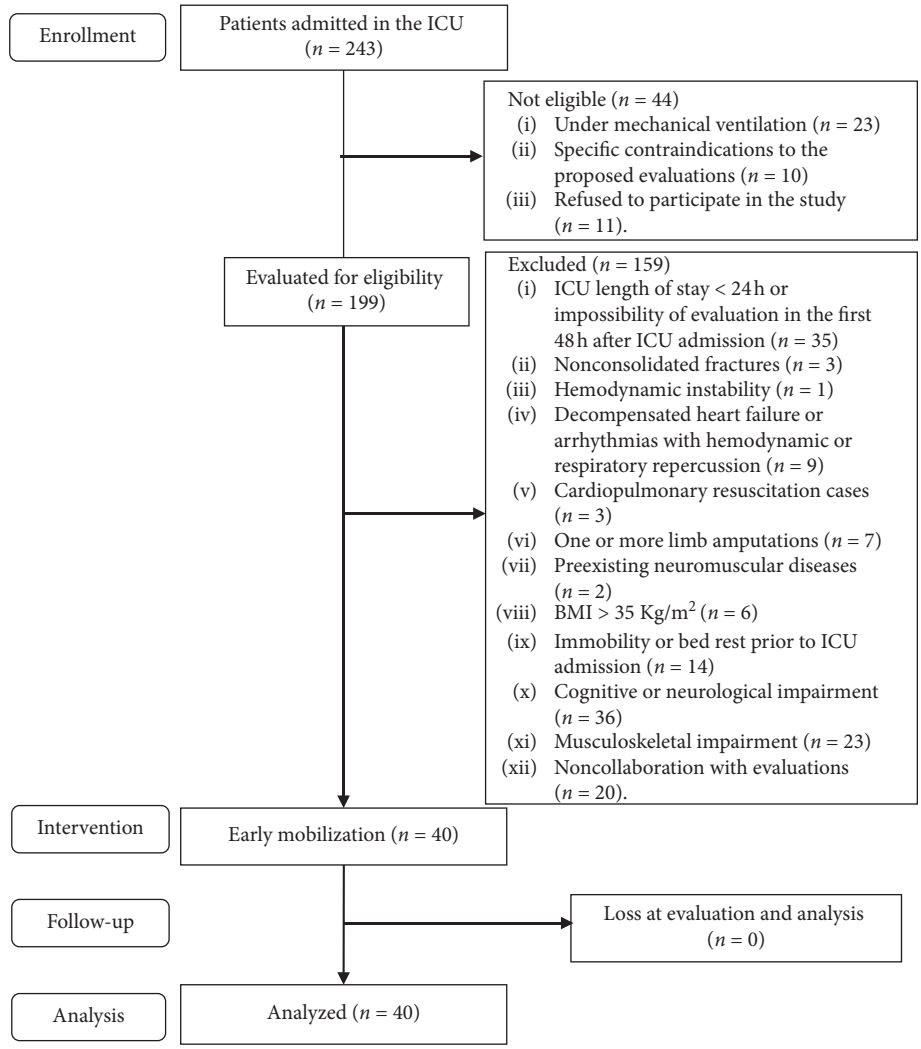


Figure 2: Flowchart of patients' enrollment.

MCID values for MEP, MRC-s, HGS, and FIM were not found in the literature. Therefore, it was not possible to tell whether the increase obtained after intervention by the patients reached a minimum relevant to the outcome assessed.

The largest effect sizes were observed for ICF-BMS (1.05), PFIT-s (0.86), and FIM (0.82). In the functional evaluation by ICF-BMS, 72.5% of the patients scored higher than MCID (Table 2).

The frequency of individuals who had positive effects was significantly higher than those who presented negative effects for all outcomes, with the exception of HGS (positive $n = 25$ (63) vs. negative $n = 15$ (37), $P = 0.154$) (Table 3).

Peripheral muscle strength evaluated by the MRC-s had a ceiling effect in 60% of the patients at admission and in 82.5% of them at discharge. The functionality evaluation by FSS-ICU had a ceiling effect with 50 to 70% variation at admission; by FIM it occurred in 35 to 62.5% of the patients, while the floor effect occurred in 52.5% of patients at ICU discharge when evaluated by ICF-BMS (Table 4).

4. Discussion

The main findings of the present study involving patients in spontaneous breathing admitted to the ICU were as follows: (1) early mobilization protocol was safe and effective to maintain and/or increase in respiratory muscle strength and functionality; (2) the largest effect sizes were obtained in the functionality measured by ICF-BMS, PFIT-s, and FIM; (3) the number of individuals with positive effects was significantly higher than those who presented negative effects for all outcomes, except HGS; and (4) MRC-s, FSS-ICU, and FIM scales presented high frequencies of ceiling effect for nonintubated patients.

This study is relevant for evaluating the effects of early mobilization in patients in ICU who are usually underestimated for being in spontaneous breathing, with respiratory and hemodynamic stability. These facts make it difficult to compare the results.

The fact that a significant increase occurred in respiratory muscle strength and functionality may indicate that executing an early mobilization protocol is able to maintain

Table 1: Characterization of sample, ICU length of stay, and adverse events.

$N = 40$	N (%)/mean (SD)
Age (years)*	55.15 (19.16)
Gender (men)†	26 (65)
BMI (kg/m^2)*	27.41 (4.97)
SAPS III (scores)*	41.68 (11.03)
SOFA (scores)*	2.4 (2.36)
Etiology†	
Surgical	14 (35)
Clinical	26 (65)
Motive of hospitalization†	
Digestive system diseases	8 (20)
Metabolic diseases	5 (12.5)
Neurological diseases	5 (12.5)
Sepsis	3 (7.5)
Respiratory system diseases	1 (2.5)
Others	4 (10)
Use of oxygen therapy (yes)†	7 (17.5)
Use of noninvasive ventilation (yes)†	5 (12.5)
ICU length of stay (days)*	3.13 (1.4)
Hospital length of stay (days)*	13.35 (9.8)
Adverse events†	0

BMI: body mass index. SAPS III: Simplified Acute Physiology Score III. SOFA: Sequential Organ Failure Assessment. *Variables expressed in mean (standard deviation). †Variables expressed in absolute frequency (percentage).

respiratory muscle strength and functional performance in patients under spontaneous breathing in critical care, even considering that they had a short ICU length of stay.

Follow-up studies after admission to the ICU describe that acquired deficits in physical, cognitive, or mental domains last from weeks to years and are related to immobility, with peripheral muscle weakness observed in 25% of patients who are under mechanical ventilation over 7 days [28, 29].

Regarding the difference in values on how minimal clinical importance is expected to consider the intervention effective to the patient, we compare our gains with the minimum clinically important differences (MCID) of MIP cited in the studies with patients under mechanical ventilation. Based on Cader et al.'s point of 10 cmH2O for maximal inspiratory pressure MCID [30], 45% of our patients reached at least that minimum. That may reflect the prevention of patients to develop ICU-acquired weakness, as the respiratory muscle weakness is an important manifestation of this adverse condition.

Although Al-Bilbeisi and McCool [31] report that nonrespiratory exercises involving trunk and upper extremities can increase the diaphragm strength, the expressive magnitude of the result in this short period of ICU stay also leads us to wonder whether the clinical impact of the protocol on recovering inspiratory muscle strength may be overestimated due to improved performance promoted by the learning effect, since manovacuometry is a volitional examination, as reported by Martyn et al. [32].

Among the functional scales used in this study, ICF-BMS detected the highest percentage of participants who reached this clinically important threshold (72.5%) for which a 7-point variation was considered [21]. FSS-ICU is considered feasible to perform in an ICU and had an MCID estimated interval of 3 points [33], which was reached by 15 (37.5%) patients from our study. PFIT-s with a MCID of 1.5 points [22] occurred in only 8 (20%) patients.

The large effect sizes for the functionality outcome reaffirm the importance of following an exercise protocol for this population, especially when we assess them by the ICF-BMS scale involving mobility activities, for instance, getting in/out of their bed to climbing stairs, and that the improvement level was 72.5% by reaching MCID, while 52.5% of the patients had the floor effect at ICU discharge. This did not occur in the study by Pieber et al. [21], where the interrater reliability, validity, sensitivity to change, and internal consistency of the same scale were evaluated and showed that it was not vulnerable to floor–ceiling effect.

In the analysis of the proportions of positive (referring to maintenance or gain) and negative (loss) effects, only HGS proportions were similar. Perhaps the reason is that the exercises protocol had lower intensity for a considerable number of participants, although for other participants it seemed effective in strengthening. This highlights the importance of individualizing exercise prescriptions for non-intubated patients on critical care, who present a certain strengthening advantage compared to those who are dependent on mechanical ventilation. In addition, it would be necessary to follow up this measure on a daily basis to understand this phenomenon pattern based on an interday variability.

However, the higher number of individuals who presented HGS ($n = 15$), MEP ($n = 11$), and MIP ($n = 9$) losses may have been influenced by (1) the tests being volitional; (2) the instruments being digital and with a scale of sensitive measurements; or (3) the need for individualized exercises for a portion of the sample, including specific training of the respiratory muscles.

No adverse effects were observed in the present study, as was reported in other early mobilization-directed clinical trial studies with patients submitted to mechanical ventilation; however, those effects were minimal and without significant difference, having the drop in SpO2 as the most cited event. Considered as a safe therapy, there has been no association between increased mobilization percentages and risk of increasing adverse events [34].

Several studies have investigated clinical instruments, methods, and tests that better depict diagnoses, prognoses, and clinical conditions, including functional tests in critical care [35–37]. This is a topic that still deserves to be investigated, considering the effects of ceilings verified for the MRC-s, FSS-ICU, and FIM functional scales and the floor effect for ICF-BMS at hospital discharge, indicating that the patients did not present peripheral muscle strength or functionality deficits prior to submission to the mobilization protocol at admission or discharge. This can either indicate the fact that the patients maintained their functionality or a good number of them reached ideal values of greater functional independence indicated by the scale [25].

The main limitations of this study are related to the implemented design (before/after intervention) because there may be an overestimation of the intervention effect

Table 2: Analysis of effect on respiratory and peripheral muscle strength and functionality.

$N = 40$	Admission mean (SD)	Discharge mean (SD)	Mean or median difference (CI 95%)	t or Z	P value	MDC	Scored MCID N (%)	Effect size (Cohen's d)
MIP (cmH_2O)	43.93 (21.95)	54.12 (21.68)	10.2 (5.78 to 14.61)	−4.67	<0.001[a]	6.04	18 (45)	0.47
MEP (cmH_2O)	50.32 (28.65)	60.30 (21.23)	10 (4 to 16)	−3.38	0.002[a]	8.18	—	0.40
MRC-s (points)	58.52 (2.84)	59.47 (1.81)	0.95 (0.01 to 1.89)	−2.05	0.023[a]	1.28	—	0.40
HGS (kgf)	25.5 (9.58)	27.5 (9.48)	2 (−0.1 to 3.5)	−1.85	0.046[b]	2.52	—	0.22
FIM (points)	54.4 (22.79)	69.48 (12.74)	15.08 (9.03 to 21.12)	−5.05	<0.001[a]	8.29	—	0.82
FSS-ICU (points)	28.7 (9.1)	32.6 (5.0)	3.9 (1.75 to 6.05)	−3.67	0.001[a]	2.88	15 (37.5)	0.53
ICF-BMS (points)	28.63 (16.19)	14.03 (11.15)	−14.6 (−19.18 to −10.02)	6.44	<0.001[a]	6.26	29 (72.5)	1.05
PFIT-s (points)	9.55 (2.34)	11.18 (1.32)	1.63 (0.91 to 2.34)	−4.57	<0.001[a]	1.00	8 (20)	0.86

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; MRC-s: Medical Research Council Score; HGS: handgrip strength; FIM: functional independence measure; FSS-ICU: Functional Status Score for the Intensive Care Unit; ICF-BMS: International Classification of Functioning, Disability and Health based Basic Mobility Scale; PFIT-s: Physical Function ICU Test Score. MDC: minimal detectable change; and scored MCID N represents the number of participants who scored at least the minimum clinical important difference value after intervention. [a]Paired Student's t-test with t-test statistic. [b]Wilcoxon test with Z test statistic.

Table 3: Binomial analysis between the frequencies of the positive and negative effects of respiratory and peripheral muscle strength and functionality.

	Positive effect N (%)	Negative effect N (%)	P value
MIP (cmH_2O)	32 (80)	8 (20)	<0.001
MEP (cmH_2O)	29 (73)	11 (27)	0.006
MRC-s (points)	38 (95)	2 (5)	<0.001
HGS (kgf)	25 (63)	15 (37)	0.154
FIM (points)	39 (98)	1 (2)	<0.001
FSS-ICU (points)	38 (95)	2 (5)	<0.001
ICF-BMS (points)	38 (95)	2 (5)	<0.001
PFIT-s (points)	39 (98)	1 (2)	<0.001

MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; MRC-s: Medical Research Council Score; HGS: handgrip strength; FIM: functional independence measure; FSS-ICU: Functional Status Score for the Intensive Care Unit; ICF-BMS: International Classification of Functioning, Disability and Health-Based Basic Mobility Scale; and PFIT-s: Physical Function ICU Test Score.

Table 4: Floor and ceiling effects on the use of MRC-s, FIM, FSS-ICU, ICF-BMS, and PFIT-s scales at the ICU admission and discharge.

Scales	Moment	Floor effect N observations (%)	Ceiling effect N observations (%)	Score range
MRC-s (score 60)	Admission	—	24 (60)	47 to 60
	Discharge	—	33 (82.5)	49 to 60
FIM (score 77)	Admission	1 (2.5)	14 (35)	11 to 77
	Discharge	—	25 (62.5)	38 to 77
FSS-ICU (score 35)	Admission	—	20 (50)	3 to 35
	Discharge	—	28 (70)	17 to 35
ICF-BMS (score 70)	Admission	3 (7.5)	—	6 to 66
	Discharge	21 (52.5)	—	6 to 47
PFIT-s (score 12)	Admission	—	4 (10)	4 to 12
	Discharge	—	22 (55)	6 to 12

MRC-s: Medical Research Council Score; FIM: Functional Independence Measure; FSS-ICU: Functional Status Score for the Intensive Care Unit; ICF-BMS: International Classification of Functioning, Disability and Health-Based Basic Mobility Scale; and PFIT-s: Physical Function ICU Test Score. Variables are expressed in absolute and relative frequencies.

with the existence of trends or sudden changes associated with the outcomes. Another factor is that the functional scales—PFIT-s and ICU-BMS—were not validated for the Brazilian population at the time of data collection and also the lack of interday data to follow up the outcomes course through ICU stay. These limitations can be

deemed as basis to propose amendments for future definitive trial.

For future definitive trial and other studies, we encourage studies in patients requiring critical care according to their severity and functional status so that the positive effects of early mobilization can be optimized at the moment of implementing an individualized protocol and encouraging the multidisciplinary team to use diagnostic and prognostic strategies as well as methods in an attempt to prevent and/or recover loss of peripheral muscle strength.

5. Conclusions

We conclude that the early mobilization protocol applied to spontaneous-breathing patients in ICU is safe and seemed effective at maintaining/increasing their respiratory muscle strength and functionality in a short period of ICU stay. Ceiling effect was high for MRC-s, FSS-ICU, and FIM scales.

Data Availability

The quantitative data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

[1] P. E. Morris, M. J. Berry, D. C. Files et al., "Standardized rehabilitation and hospital length of stay among patients with acute respiratory failure: a randomized clinical trial," *JAMA*, vol. 315, pp. 2694–2702, 2016.

[2] J. A. Dammeyer, N. Baldwin, D. Packard et al., "Mobilizing outcomes: implementation of a nurse-led multidisciplinary mobility program," *Critical Care Nursing Quarterly*, vol. 36, pp. 109–119, 2013.

[3] G. Bourdin, J. Barbier, J. F. Burle et al., "The feasibility of early physical activity in intensive care unit patients: a prospective observational one-center study," *Respiratory Care*, vol. 55, no. 4, pp. 400–407, 2010.

[4] E. Calvo-Ayala, B. A. Khan, M. O. Farber et al., "Interventions to improve the physical function of icu survivors: a systematic review," *Chest*, vol. 144, pp. 1469–1480, 2013.

[5] S. M. Parry, L. Denehy, L. J. Beach et al., "Functional outcomes in ICU–what should we be using?-an observational study," *Critical Care*, vol. 19, p. 127, 2015.

[6] K. J. Stuempfle and D. G. Drury, "The physiological consequences of bed rest," *Health Sciences Faculty Publications*, vol. 6, pp. 32–41, 2007.

[7] K. Stiller, A. Phillips, and P. Lambert, "The safety of mobilisation and its effect on haemodynamic and respiratory status of intensive care patients," *Physiotherapy Theory and Practice*, vol. 20, pp. 175–185, 2004.

[8] Z. Li, X. Peng, B. Zhu, Y. Zhang, and X. Xi, "Active mobilization for mechanically ventilated patients: a systematic review," *Archives of Physical Medicine and Rehabilitation*, vol. 94, no. 3, pp. 551–561, 2013.

[9] J. Adler and D. Malone, "Early mobilization in the intensive care unit: a systematic review," *Cardiopulmonary Physical Therapy Journal*, vol. 23, no. 1, pp. 5–13, 2012.

[10] T. Castelino, J. F. Fiore, P. Niculiseanu, T. Landry, B. Augustin, and L. S. Feldman, "The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: a systematic review," *Surgery*, vol. 159, no. 4, pp. 991–1003, 2016.

[11] S. Cameron, I. Ball, G. Cepinskas et al., "Early mobilization in the critical care unit: a review of adult and pediatric literature," *Journal of Critical Care*, vol. 30, no. 4, pp. 664–672, 2015.

[12] E. H. Skinner, S. Berney, S. Warrillow, and L. Denehy, "Rehabilitation and exercise prescription in Australian intensive care units," *Physiotherapy*, vol. 94, no. 3, pp. 220–229, 2008.

[13] N. A. Ali, J. M. O'Brien, S. P. Hoffmann et al., "Acquired weakness, handgrip strength, and mortality in critically ill patients," *American Journal of Respiratory and Critical Care Medicine*, vol. 178, no. 3, pp. 261–268, 2008.

[14] N. R. Samosawala, K. Vaishali, and B. C. Kalyana, "Measurement of muscle strength with handheld dynamometer in Intensive Care Unit," *Indian Journal of Critical Care Medicine*, vol. 20, no. 1, pp. 21–26, 2016.

[15] American Thoracic Society, "ATS/ERS Statement on respiratory muscle testing," *American Journal of Respiratory and Critical Care Medicine*, vol. 166, pp. 518–624, 2002.

[16] J. A. Neder, S. Andreoni, M. C. Lerario, and L. E. Nery, "Reference values for lung function tests: II. Maximal respiratory pressures and voluntary ventilation," *Brazilian Journal of Medical and Biological Research*, vol. 32, no. 6, pp. 719–727, 1999.

[17] H. C. Roberts, H. J. Denison, H. J. Martin et al., "A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach," *Age and Ageing*, vol. 40, no. 4, pp. 423–429, 2011.

[18] M. M. Schlüssel, L. A. dos Anjos, M. T. L. de Vasconcellos, and G. Kac, "Reference values of handgrip dynamometry of healthy adults: a population-based study," *Clinical Nutrition*, vol. 27, no. 4, pp. 601–607, 2008.

[19] C. A. Prinsen, S. Vohra, M. R. Rose et al., "Core Outcome Measures in Effectiveness Trials (COMET) initiative: protocol for an international Delphi study to achieve consensus on how to select outcome measurement instruments for outcomes included in a "core outcome set"," *Trials*, vol. 15, p. 247, 2014.

[20] T. A. Dodds, D. P. Martin, W. C. Stolov, and R. A. Deyo, "A validation of the Functional Independence Measurement and its performance among rehabilitation inpatients," *Archives of Physical Medicine and Rehabilitation*, vol. 74, no. 5, pp. 531–536, 1993.

[21] K. Pieber, M. Herceg, T. Paternostro-Sluga et al., "Reliability, validity, sensitivity and internal consistency of the ICF based Basic Mobility Scale for measuring the mobility of patients with musculoskeletal problems in the acute hospital setting: a prospective study," *BMC Musculoskeletal Disorders*, vol. 16, p. 187, 2015.

[22] L. Denehy, N. A. de Morton, E. H. Skinner et al., "A physical function test for use in the intensive care unit: validity, responsiveness, and predictive utility of the physical function ICU test (scored)," *Physical Therapy*, vol. 93, no. 12, pp. 1636–1645, 2013.

[23] M. Riberto, M. H. Miyazaki, S. S. H. Jucá et al., "Validation of the Brazilian version of functional independence measure," *Acta Fisiátrica*, vol. 11, pp. 3–7, 2004.

[24] V. Z. M. d. Silva, J. A. d. Araújo Neto, G. Cipriano Júnior et al., "Brazilian version of the Functional Status Score for the ICU: translation and cross-cultural adaptation," *Revista Brasileira de Terapia Intensiva*, vol. 29, pp. 34–38, 2017.

[25] A. Nordon-Craft, M. Schenkman, L. Edbrooke, D. J. Malone, M. Moss, and L. Denehy, "The physical function intensive care test: implementation in survivors of critical illness," *Physical Therapy*, vol. 94, no. 10, pp. 1499–1507, 2014.

[26] P. E. Morris, A. Goad, C. Thompson et al., "Early intensive care unit mobility therapy in the treatment of acute respiratory failure*," *Critical Care Medicine*, vol. 36, no. 8, pp. 2238–2243, 2008.

[27] C. E. S. R. Barros, A. M. S. Lima, A. F. Vilaça et al., "Impact of standardized mobilization in mechanically ventilated patients on respiratory muscular strength," *European Respiratory Journal*, vol. 46, 2015.

[28] D. M. Needham, J. Davidson, H. Cohen et al., "Improving long-term outcomes after discharge from intensive care unit," *Critical Care Medicine*, vol. 40, no. 2, pp. 502–509, 2012.

[29] N. H. Merbitz, K. Westie, J. A. Dammeyer, L. Butt, and J. Schneider, "After critical care: challenges in the transition to inpatient rehabilitation," *Rehabilitation Psychology*, vol. 61, no. 2, pp. 186–200, 2016.

[30] S. A. Cader, R. G. de Souza Vale, J. C. Castro et al., "Inspiratory muscle training improves maximal inspiratory pressure and may assist weaning in older intubated patients: a randomised trial," *Journal of Physiotherapy*, vol. 56, pp. 171–177, 2010.

[31] F. Al-Bilbeisi and F. Dennis Mccool, "Diaphragm recruitment during nonrespiratory activities," *American Journal of Respiratory and Critical Care Medicine*, vol. 162, no. 2, pp. 456–459, 2000.

[32] J. B. Martyn, R. H. Moreno, P. D. Paré, and R. L. Pardy, "Measurement of inspiratory muscle performance with incremental threshold loading," *American Review of Respiratory Disease*, vol. 135, no. 4, pp. 919–923, 1987.

[33] M. Huang, K. S. Chan, J. M. Zanni et al., "Functional status score for the ICU," *Critical Care Medicine*, vol. 44, 2016.

[34] W. D. Schweickert, M. C. Pohlman, A. S. Pohlman et al., "Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial," *Lancet*, vol. 373, pp. 1874–1882, 2009.

[35] C. J. Tipping, M. J. Bailey, R. Bellomo et al., "The ICU mobility scale has construct and predictive validity and is responsive. A multicenter observational study," *Annals of the American Thoracic Society*, vol. 13, no. 6, pp. 887–893, 2016.

[36] K. A. Robinson, W. E. Davis, V. D. Dinglas et al., "A systematic review finds limited data on measurement properties of instruments measuring outcomes in adult intensive care unit survivors," *Journal of Clinical Epidemiology*, vol. 82, 2017.

[37] C. Perme, R. K. Nawa, C. Winkelman, and F. Masud, "A tool to assess MoBility status in CritiCally ill patients: the perMe intensive Care unit MoBility sCore," *Methodist DeBakey Cardiovascular Journal*, vol. 10, no. 1, pp. 41–49, 2014.