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Uninterrupted Actigraphy Recording to Quantify Physical Activity and Sedentary Behaviors in Mechanically Ventilated Adults: A Feasibility Prospective Observational Study

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ABSTRACT

Purpose: We evaluated the feasibility of quantification of physical activity (PA) and sedentary behaviors (SB) using actigraphy during an entire intensive care unit (ICU) length of stay.

Methods: A prospective study was performed in a 12-bed ICU. Triaxial accelerometers were fitted on the right ankle of mechanically ventilated adults. Twenty accelerometers were available to guarantee uninterrupted actigraphy recording 24 hours/day. Data were analyzed: (1) between awakening and ICU discharge to quantify daytime PA/SB and (2) between admission and ICU discharge to quantify day/nighttime inactivity. Secondarily, we assessed the relationship between inactivity/SB and clinical variables.

Results: Thirty patients were enrolled, obtaining 5477 recording hours. No patient reported discomfort or injury. The median (min-max) delay time between admission and accelerometer installation was 2.1 (0.0-11.9) hours. Actigraphy recording duration was 5.4 (2.2-34.4) days. The time spent in SB and PA (percentage of minutes per hour) was 94.7% and 5.3%, respectively. PA was stratified by light, moderate, and vigorous levels equating to 91.8%, 7.7%, and 0.5%, respectively. Inactivity time ($r = 0.991$, $P \leq .001$) and SB ($r = 0.859$, $P \leq .001$) were strongly correlated with ICU length of stay.

Conclusions: Quantifying PA levels with continuous monitoring through actigraphy is feasible, demonstrating prolonged periods of inactivity/SB. This study highlights that uninterrupted actigraphy could contribute to pursuing the optimal dose and the intervention fidelity of the ICU mobilization in the subsequent clinical trials.

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Physical activity (PA) is defined as any body movement generated by skeletal muscles that increases energy expenditure above resting metabolic rate.[1] The World Health Organization (WHO) has provided recommendations for the general population, highlighting that healthy adults should achieve at least 150 to 300 minutes of moderate intensity level or 75 to 150 minutes of vigorous intensity level per week.[2] Furthermore, an even stronger recommendation is that adults should limit the amount of time spent on sedentary behaviors (SB), defined as any waking behaviors characterized by an energy expenditure of 1.5 metabolic equivalents (METs) or less.[2] Although WHO statements on PA also comprise specific recommendations for older adults, children, adolescents, and people with chronic conditions or disabilities, no recommendations exist for hospitalized patients who may have restricted ability to participate in activity. Moreover, a stay in the intensive care unit (ICU) leads to bed rest and immobility due to the severity of the illness, sedation, mechanical ventilation, physical restraints, and cultural barriers to early mobilization.[3,4] Data from 1-day point studies demonstrate that patients with mechanical ventilation only achieve out-of-bed activities as part of routine care between 16% and 24% of the total

ICU stay.[5-10] Consequently, immobility increases the risk of ICU-acquired weakness and postintensive care syndrome, including new physical, cognitive, and mental complications up until 5 years after an ICU stay.[4,11,12] Accordingly, the ICU Liberation A2F Bundle[13] and the updated 2018 Pain, Agitation/sedation, Delirium, Immobility, and Sleep (PADIS) guideline[14] recommend minimizing immobility to improve patient outcomes.

Despite the feasibility and safety of early mobilization and physical rehabilitation, most patients are immobilized in the ICU.[8,10,15] Low patient activity levels increase the risk for impairments in physical functioning and, thus, are a major concern for clinicians and researchers to assess accurately and treat.[16,17] Numerous measurement instruments are available to identify these problems in critically ill patients (ie, ICU Mobility Scale [IMS], Functional Status Score for the ICU [FSS-ICU], Chelsea Critical Care Physical Assessment Tool [CPAx], and Physical Function in ICU Test [PFIT-s]).[18,19] Such tests could partially capture a patient's condition but not necessarily provide a complete and actual functional status. Alternatively, direct methods (direct observation), indirect methods (video recording or electronic health record documentation), and accelerometer-based sensors[20] allow a comprehensive measure of PA. Actigraphy, in particular, or sensor-based measurement methods are objective, unobtrusive, and can measure continuously and independently of the time of the day, clinician presence, or body location.[21] The use of this wearable activity monitor embedded with accelerometers is progressively common in health care, specifically in ambulatory and some acute care inpatient populations.[21-23] Actigraphy has been used in the ICU to measure diverse outcomes related to body motion, including sleep quality, sedation level, activity, inactivity, mobility, and step counts.[21-23] Despite the emerging data on actigraphy in critically ill patients and ICU survivors, the assessment of intensity levels of PA during the ICU stay is still limited, anticipating that patients are profoundly inactive.[21]

Considering 2 systematic reviews from 2015[23] and 2019,[21] continuous actigraphy recording in the ICU has ranged from 2 hours to 10 days,[24] but no published articles on uninterrupted actigraphy measurement during the whole ICU stay of adults who were mechanically ventilated are available. Therefore, the aim of this study is to evaluate the feasibility of quantifying the activity and inactivity time from ICU admission to ICU discharge as well as PA levels and SB from awakening to ICU discharge in mechanically ventilated adults using uninterrupted actigraphy records. A secondary aim of this study is to explore the relationships between actigraphy data with clinical outcomes.

METHODS

This feasibility prospective observational study was conducted in an academic ICU with 12 beds, including care for respiratory, surgical, neurosurgical, trauma, and medical patients. Consecutively, eligible patients were recruited at ICU admission between October 2018 and January 2019 and followed up until their ICU discharge. The protocol of this study was registered (2017-104) on the Research and Clinical Trials Unit at Clínica Alemana Universidad del Desarrollo, including local institutional ethics committee approvals. This study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, and the feasibility objectives are presented under the established framework proposed by Orsmond and Cohn[25] adjusted from an observational point of view.

Participants

We included adult patients (>18 years) who received invasive mechanical ventilation in the ICU. The exclusion criteria were patients with a do-not-resuscitate order, complete paralysis in one or more limbs, use of mechanical ventilation at another site prior to the ICU admission, limb amputation, patient awakening before the first 24 hours since ICU admission (to ensure at least 24 hours of actigraphy recording between ICU admission and awakening), lacking a level of awakening before ICU discharge, and previous functional dependence (defined as an FSS-ICU score <30 points based on the proxy information). The proxy of each eligible patient was contacted in person at ICU admission to request their informed consent to participate. The patient was asked for confirmation or rejection to participate when an adequate level of awareness was achieved (defined as the ability to follow 5 simple commands according to the De Jonghe criteria[26]) and being delirium-free based on the Confusion Assessment Method for the ICU.[27]

Study Protocol

This study comprised 3 time points: (1) ICU admission, defined as within the first 12 hours from ICU admission; (2) awakening, defined as the first time when a patient responded to 5 simple commands[26]; and (3) ICU discharge, defined as the moment when a patient met medical criteria for discharge from the unit. All patients received standard ICU care involving sedation and analgesia management, repositioning every 2 hours, bed bath twice per day, and upper limb restraint use for deeply sedated and ventilated patients. Physiotherapists followed local protocols tailoring early mobilization modalities according to the patient's needs in the daytime, including passive/active range of motion, bed cycling, tilt-table, progressive mobility, and neuromuscular electrical stimulation. Respiratory physiotherapy was also available 24 hours per day and 7 days per week.

Actigraphy Protocol

A triaxial accelerometer (Actigraph GT9X–Link, ActiGraph, Pensacola, Florida)[28] was fitted on the right ankle from ICU admission to ICU discharge. The right ankle was selected, as this location had less interference

with clinical procedures than the wrist and is a valid recording method.[29] The accelerometer was temporarily removed only during magnetic resonance imaging, computed tomography, surgical procedures, or any clinical test outside the room. Twenty accelerometers were available to guarantee uninterrupted actigraphy recording by 24 hours per day and during the whole ICU stay, ensuring replacements as a backup when the battery level fell below 10% or when necessary. The accelerometers were charged at 100% and initialized before fitting on the patient. The time sampling interval or epoch used was 5 seconds, and the sampling frequency was 90 Hz,[30] with the gyroscope function off. Actigraphy data were extracted through the ActiLife version 6.13.3 (ActiGraph, Pensacola, Florida), using the low-frequency extension function[31] to increase the sensitivity of low-intensity movements. Because this study measured actigraphy data continuously, we analyzed all records as wear time, assuming no nonwear time. Data were filtered to include records from the first installation to the final device removal. To attain this, data were exported to Excel, eliminating the first and last hours of each record.

Actigraphy Outcomes

Data were analyzed in 2 periods, considering the last definitions of PA and SB from the WHO, where only the time awake is considered.[1,2] First, we extracted PA and SB considering the daytime data (8:00 am to 8:00 pm) from awakening to ICU discharge, pursuing only awake patients (not necessarily without sedation, but with a low level of sedation to allow an appropriate cooperative level). We reported the time spent in PA and SB in minutes per hour using the Freedson et al classification,[30] defined as counts/minute or movements/minute: SB = 0 to 99, light PA = 100 to 1951, moderate PA = 1952 to 5724, vigorous PA = 5725 to 9498, and very vigorous PA 9499 or more. For the analysis, we merged the vigorous with the very vigorous level. Second, we measured activity and inactivity considering both the day- and the nighttime data (24 hours per day) between ICU admission and ICU discharge (entire ICU length of stay). Time spent in activity and inactivity were reported in minutes per hour,[30] where between 0 and 99 counts/minute are considered inactivity time, whereas more than 99 counts/minute are considered activity time.

Feasibility Outcomes

According to the framework proposed by Orsmond and Cohn,[25] the feasibility outcomes evaluated were: (1) evaluation of recruitment capability (ie, recruitment duration, patients characteristics, reasons for refusal or ineligibility, consent rate) and resulting sample characteristics (ie, age, gender, admission diagnosis, severity of the disease), (2) evaluation and refinement of data collection procedures and outcome measures (ie, body location of the accelerometer, storage corruption of accelerometer, functional outcomes assessment on awakening and at ICU discharge), (3) evaluation of the acceptability and suitability of the study procedures (ie, unexpected adverse events as device loss or malfunction), skin injuries (redness, rash, or skin breakdown), (4) evaluation of the resources and ability to manage and implement the study (ie, number of accelerometers installed per patient, delay time between ICU admission and accelerometer installation, recording duration of each accelerometer), and (5) preliminary evaluation of participant responses (correlations of inactivity time and SB). We explored correlations of ICU inactivity time and SB with age, body mass index, disease severity, ICU length of stay, duration of mechanical ventilation, muscle strength, and mobility. We used the Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring system to measure the disease severity. Muscle strength was measured using the Medical Research Council Sum Score (MRC-SS), which has very good interrater reliability (intraclass correlation coefficient [ICC] = 0.86-0.99)[32] and good construct validity with PFIT-s ($\rho = 0.8$),[33] FSS-ICU ($\rho = 0.67$-0.72),[33,34] and IMS (0.57).[33] Mobility was measured using the Chilean version of the FSS-ICU,[35,36] which has excellent interrater reliability (ICC = 0.96),[37] excellent construct validity with the ICU length of stay ($\rho = -0.77$) and duration of mechanical ventilation ($\rho = -0.62$), and low ceiling/floor effect (0%-10%).[34] The MRC-SS and the FSS-ICU were measured on awakening and at ICU discharge.

Data Analysis

The sample size was calculated in 23 patients using the QFAB Power Calculator web application.[34] The calculation was based on power = 0.9, significance threshold = 0.01, and a correlation of 0.7 between the FSS-ICU and actigraphy. We decided on an oversampling of 15% due to the potential loss of accelerometer recordings, resulting in 27 patients being needed for the study. Since variables did not follow a normal distribution, medians and interquartile range [IQR] were used for numerical variables, while absolute and relative frequencies were used for categorical variables. The time spent in PA, SB, activity, and inactivity was also reported as a percentage, dividing minutes into 1 hour. Clinical and demographic data were recorded using a custom-made database in Research Electronic Data Capture (REDCap). The Spearman ρ correlation coefficient was used to test the correlations of inactivity time and SB, according to the Domholdt categories, where 0.00 to 0.25 was little, 0.26 to 0.49 was weak, 0.50 to 0.69 was moderate, 0.70 to 0.89 was strong, and 0.90 to 1.00 was very strong correlation.[38] Correlations were considered to be significant at the 0.05 level (2-tailed) or the 0.01 (2-tailed) as appropriate. All statistical analyses were completed using Stata/IC 15.0 (StataCorp LP, College Station, Texas).

RESULTS

Participants

Of the 72 patients who met the selection criteria at ICU admission, 1 proxy declined to participate because "the device would interfere clinically" (consent rate = 98.6%). During the follow-up, we lost 17 patients due to transfer to another hospital (n = 7), death (n = 5), lacking level of awakening (n = 3), and do-not-resuscitate order (n = 2). Subsequently, 54 patients were eligible for data extraction. Twenty-three patients were not included in the analyses due to the actigraphy recording less than 24 hours between admission and awakening. One patient's actigraphy record was corrupted, yielding 30 patients for the analysis recruited over 3 months (see Table 1).

TABLE 1. Characteristics of the Study Participants (n = 30)

Variable	Median [IQR] or n (%)
Age, y	65.0 [56.0-74.5]
Body mass index, kg/m^2	25.7 [23.6-27.4]
Female gender	17 (56.7)
APACHE II score	16.0 [13.5-20.0]
Admission diagnosis	
Sepsis	9 (30.0)
Coma	6 (20.0)
Oncological	6 (20.0)
Hypovolemic shock	4 (13.3)
Respiratory	3 (10.0)
Liver transplantation	1 (3.3)
Trauma	1 (3.3)
Duration of mechanical ventilation, d	2.6 [1.5-5.4]
ICU length of stay, d	5.7 [3.7-8.9]
Time to awakening, d	2.2 [1.0-4.2]
MRC-SS, total score	
On awakening	50 [37-54]
At ICU discharge	56 [53-59]
Number of patients with ICU-AW[a]	
On awakening	11 (36.6)
At ICU discharge	6 (20.0)
FSS-ICU, total score	
On awakening	18 [9.0-25.5]
At ICU discharge	28 [22.0-32.0]

APACHE II, Acute Physiology and Chronic Health Evaluation II; FSS-ICU, Functional Status Score for the Intensive Care Unit; ICU, intensive care unit; ICU-AW, intensive care unit acquired weakness; MRC-SS, Medical Research Council Sum Score.

[a]The ICU-AW was determined with less than 48 points of the MRC-SS.

TABLE 2. Summary of Actigraphy Feasibility Results

Actigraphy Feasibility Variables	Median (Min-Max) or n (%)
Number of accelerometers installed by patient	1.0 (1.0-3.0)
1	19.0 (63.3)
2	9.0 (30.0)
3	2.0 (6.7)
Total actigraphy recording duration, d	5.4 (2.2-34.4)
≤5	15 (50.0)
6-10	10 (33.3)
11-15	2 (6.7)
16-20	1 (3.3)
>20	2 (6.7)
Recording duration of each accelerometer, d	3.5 (0.4-16.8)
Time of accelerometer installation at ICU admission, h	2.1 (0.0-11.9)
Number of accelerometers with data corruption	1 (3.2)
Number of skin injuries	0 (0.0)
Number of losses of devices	0 (0.0)

ICU, intensive care unit.

Actigraphy Feasibility Results

Of the 30 patients, we obtained actigraphy data from 43 devices with 5477 recording hours (see Table 2). No devices were lost, and no patients reported discomfort or skin injury related to the accelerometer contact. The maximum number of accelerometers running simultaneously was 7 (35%) out of 20 available for the study. The total actigraphy recording median time was 5.4 [IQR = 3.3-8.6] days, including a maximum of 34.4 days in 1 patient. Of the overall recording time, 7.7 days corresponded to activity, and 220.5 days to inactivity. Between awakening and ICU discharge, the median time spent in SB was 57.5 [IQR = 56.2-58.3] minutes/hour, whereas in PA was 2.5 [IQR = 1.7-3.8] minutes/hour. Differentiating the median time spent in PA, light, moderate, and vigorous/very vigorous levels were 2.2 [IQR = 1.4-3.5], 0.2 [IQR = 0.1-0.4], and 0.0 [IQR = 0.0-0.0] minutes/hour, respectively. Between ICU admission and ICU discharge, patients were inactive for a median of 58.5 [IQR = 57.6-58.9] minutes/hour, whereas the active time was 1.5 [IQR = 1.1-2.4] minutes/hour. These results are reported as percentages in the Figure. In general, correlations were slightly higher for inactivity time than for SB. The higher correlation was between inactivity time and ICU length of stay. All correlations are presented in Table 3.

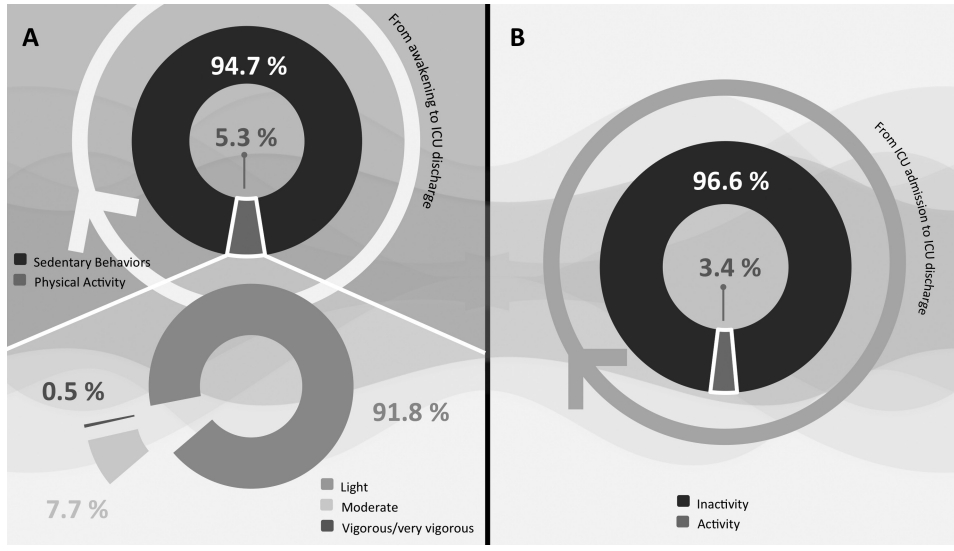

FIGURE. Percentage of Time Spent in Physical Activity, Sedentary Behaviors, Activity, and Inactivity Measured by Actigraphy During Intensive Care Unit Stay. (A) Percentage of time spent in physical activity and sedentary behaviors during the daytime, from awakening to ICU discharge. For the total percentage of physical activity, intensity levels are also presented. (B) Percentage of time spent in activity and inactivity during the daytime/nighttime from ICU admission to ICU discharge. ICU indicates intensive care unit.

DISCUSSION

Our study is the first to demonstrate that uninterrupted actigraphy monitoring for long periods is feasible and demonstrates that PA levels are low throughout ICU stay. Moreover, patients in our study were inactive for 96.6% of the total time in the ICU. Clinically, actigraphy monitoring provides rehabilitation clinicians with objective data, which we suggest should be used to alert clinicians about the need to interrupt inactivity to initiate early mobilization.

The feasibility of actigraphy in the ICU setting has been tested previously, showing measurement of activity and inactivity up to 2 days.[39] Several studies declare that the registration time is a limitation in their results.[20,39-41] Our study provides data up to 34 days of actigraphy records, demonstrating the possibility to measure

TABLE 3. Correlations of Inactivity Time and Sedentary Behaviors With Clinical Variables (n = 30)[a]

Clinical Variables	Inactivity Time[b]	Sedentary Behaviors[c]
Age	0.503 ($P = .005$)[d]	0.513 ($P = .004$)[d]
Body mass index	0.107 ($P = .574$)	0.018 ($P = .927$)
APACHE II score	0.525 ($P = .003$)[d]	0.350 ($P = .058$)
MRC-SS on awakening	−0.553 ($P = .002$)[d]	−0.396 ($P = .030$)[e]
MRC-SS at ICU discharge	−0.547 ($P = .002$)[d]	−0.525 ($P = .003$)[d]
ICU length of stay	0.991 ($P \leq .001$)[d]	0.859 ($P \leq .001$)[d]
Duration of mechanical ventilation	0.901 ($P \leq .001$)[d]	0.678 ($P \leq .001$)[d]
FSS-ICU on awakening	−0.716 ($P \leq .001$)[d]	−0.621 ($P \leq .001$)[d]
FSS-ICU at ICU discharge	−0.787 ($P \leq .001$)[d]	−0.746 ($P \leq .001$)[d]

APACHE II, Acute Physiology and Chronic Health Evaluation II; FSS-ICU, Functional Status Score for the Intensive Care Unit; ICU, intensive care unit; MRC-SS, Medical Research Council Sum Score.

[a]Correlations were calculated with Spearman ρ. The conceptual distinction between "sedentary behaviors" and "inactivity time" lies in the fact that "sedentary behaviors" is not applicable for noncooperative patients who are asleep or sedated.

[b]Considering the day and nighttime data from ICU admission to ICU discharge.

[c]Considering the daytime data from awakening to ICU discharge.

[d]Correlation is significant at the 0.01 level (2-tailed).

[e]Correlation is significant at the 0.05 level (2-tailed).

continuous actigraphy during the whole ICU stay. However, challenges remain related to the standardization of methodological features of actigraphy protocols that might be considered in future clinical studies, as reported in previous systematic reviews.[21,23] The underreporting of relevant variables for the actigraphy setting is also mentioned, limiting the reproducibility of the mentioned methods and the opportunity to perform comparisons between different studies. The high heterogeneity of the selection of the type of device includes different types of accelerometers, gyroscopes, and pedometers.

Additionally, great variability exists in the selection and reporting of the sampling frequency and epoch duration,[21] likely because not all devices allow the programming of all variables or the modification of the algorithm.[20,39,40] In our study, the selection of the actigraph allowed us to select the shortest epoch lengths, increasing the PA metering accuracy. The body location for wearing the device has been at the chest, hip, thigh, wrist, and ankle, depending on the specific outcome to be measured, such as gait speed[42] and body position.[41,43] The ankle was chosen for our study due to potential interference with routine ICU procedures created by placing a device on the wrist and the right ankle to standardize the measurement in all subjects. Schwab et al, in 2019,[21] highlighted the need to standardize the body location of the actigraph. In addition, the approach to the concept of PA has been different between studies.[20,24,40,43,44] The selection of different criteria is reported to classify activity, inactivity, PA intensity levels, and SB in the ICU setting. According to the data provided by actigraphy, some PA classifications have been made according to the intensity of the movement,[41] body position,[20,43] cut-off points in METs,[24] and counts per minute.[45] On the other hand, previous studies have considered SB according to the body position.[41,43] The modern accelerometer used in this study provides data in counts per minute, vector magnitude, the sum of count for 3-axis, METs, number of sedentary bouts/breaks, step count, and time spent in SB/inactivity/PA levels. Considering that most mobility events are low intensity and infrequent in the ICU setting, we decided to quantify the activity according to the amount of movement in the 3-axis and consider the classification of PA and inactivity according to WHO definitions.[2] The use of this technology has improved in recent years with the ability to sensitively detect changes in PA levels for extended periods, providing avenues to assess and potentially intervene by increasing the frequency of PA and early mobilization.[39]

Despite the international adoption of early mobilization practices spread worldwide, the ICU remains a setting that promotes bed rest and inactivity. Point prevalence and behavioral mapping studies from Australia and New Zeland,[10] Germany,[8] Brazil,[7] Switzerland,[5] the United Kingdom,[46] and the United States[9] previously revealed that mechanically ventilated patients in the ICU are highly inactive with limited mobility practices. These findings indicate that patients requiring mechanical ventilation via endotracheal tube have even less out-of-bed mobility. The results of these studies are clinically relevant, but the design may unintentionally omit periods of PA through the selected sampling technique, typically one 24-hour period in behavioral mapping studies, and may not capture practice outside their study windows. Uninterrupted actigraphy enhances the sampling technique to capture the entire ICU stay. In a recent randomized controlled trial, actigraphy was used to assess the PA of a control and intervention group showing significant differences in the inactivity time (95.7% vs 92.3%, $P \leq .001$), but both groups were highly clinically inactive.[45] Considering actigraphy data from observational studies, the inactivity time during the ICU stay has been reported from 64% to 83% in studies comprising ventilated and nonventilated patients,[39,40] and from 96% to 98% in patients requiring invasive mechanical ventilation.[24,41] The findings from our study complement prior works but expand to reveal that regardless of ICU timeline (pre- or postawakening), patients are highly inactive, maintaining SB after awakening.

Findings from our study demonstrate that PA levels are strongly correlated to physical functioning. Actigraphy records have been previously compared with the PFIT-s, de Morton Mobility Index, MRC-SS, FSS-ICU, handgrip, Short Physical Performance Battery, and the CPAx, showing moderate to very strong correlations.[34,41,44,47] Accordingly, the relationship between PA and physical functioning is not novel,[24,41,44] but the data emphasize the need for mobilization in the ICU. Moreover, timely PA and mobilization may mitigate the long-term consequences of critical illness and prevent disability,[48] and emphasizing assessment in the ICU may enhance the frequency and dosage of activity.[49]

The optimal early mobilization and physical rehabilitation dose remain an important clinical question.[49] Actigraphy may play an important role in understanding the prescription of exercise in the ICU regarding the main dimensions of the dosage, type, intensity, frequency, and duration of each intervention.[49,50] Before determining the optimal dose of ICU activity, a vital step is to identify and quantify problems related to immobility to allow accurate decision-making[16,17,20] and provide objective data to the ICU team, which may stimulate discussion and promote the implementation of the A2F bundle.[51] For example, if future actigraphy monitoring enables real-time and bedside information, ICU staff would be aware of personalized mobilization needs. Moreover, actigraphy may have an important role in addressing or answering questions about negative ICU physical rehabilitation studies, as previous randomized controlled trials have failed to demonstrate definite benefits.[52] These studies measured the time spent with rehabilitation but did not continuously assess PA levels. Thus, the control group

could have hypothetically a different dosage of PA than the intervention group that might be detected if data were available over a continuous period.[53] We highly recommend that future randomized controlled trials track PA through uninterrupted actigraphy as a potential confounder to outcomes, uncovering the intervention fidelity.[54] Considering that critically ill patients belong to a low mobility setting, subsequent studies should focus on calibrating and validating actigraphy in the ICU setting, considering cut-off points adjusting PA intensities in critically ill patients.

A number of limitations should be noted. First, the sample size calculation was not specifically designed for this study, including data from a single center, limiting generalizability in other ICUs. Additionally, the sample size and study design were not suitable to demonstrate representative correlations in this study. Second, we disabled the gyroscope function of the accelerometers, which limited the possibility of reporting the body position. This was chosen to allow longer battery duration minimizing accelerometer replacements. Third, the discrimination of the involuntary from the voluntary movement of the activity time was not possible, which could increase even more of the inactive time recording of critically ill patients. We also did not identify sleep time; thus, the findings from this study could not be useful for sleep quality studies. Fourth, due to the observational nature, we should not assume causality in the correlations of this study; however, our data were similar to previous correlations between actigraphy data and physical functioning scales. Finally, we analyzed data using algorithms and classifications designed for non-ICU patients, which could lead to misinterpretations of the actigraphy data in critically ill patients. Future studies should develop actigraphy algorithms tailored for the ICU setting to address this limitation.

CONCLUSIONS

The quantification of PA levels and SB was feasible following a dedicated actigraphy protocol during the whole ICU stay, highlighting that adults who require mechanical ventilation spent most of their time in SB or inactivity, which is consistent with prior studies. Additionally, when patients engaged in PA, it was mostly light intensity. Further studies are needed to accurate actigraphy measurement among low mobility settings, as in the ICU population, to pursue the optimal dose and the intervention fidelity of the ICU mobilization.

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