Inactivity May Identify Older Intensive Care Unit Survivors at Risk for Post–Intensive Care Syndrome

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Background Older adults (≥age 65) admitted to an intensive care unit (ICU) are profoundly inactive during hospitalization. Older ICU survivors often experience life-changing symptoms, including cognitive dysfunction, physical impairment, and/or psychological distress, which are components of post–intensive care syndrome (PICS).

Objectives To explore trends between inactivity and symptoms of PICS in older ICU survivors.

Methods This study was a secondary analysis of pooled data obtained from 2 primary, prospective, cross-sectional studies of older ICU survivors. After ICU discharge, 49 English- and Spanish-speaking participants who were functionally independent before admission and who had received mechanical ventilation while in the ICU were enrolled. Actigraphy was used to measure post-ICU hourly activity counts (12:00 AM to 11:59 PM). Selected instruments from the National Institutes of Health Toolbox and Patient-Reported Outcomes Measurement Information System were used to assess symptoms of PICS: cognitive dysfunction, physical impairment, and psychological distress.

Results Graphs illustrated trends between inactivity and greater symptom severity of PICS: participants who were less active tended to score worse than one standard deviation of the mean on each outcome. Greater daytime activity was concurrently observed with higher performances on cognitive and physical assessments and better scores on psychological measures.

Conclusions Post-ICU inactivity may identify older ICU survivors who may be at risk for PICS and may guide future research interventions to mitigate symptom burden. (*American Journal of Critical Care.* 2024;33:95-104)

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Inactivity and immobility in hospitalized older adults have been previously described as an epidemic that may contribute to adverse outcomes such as functional decline and new institutionalization.[1] Older adults admitted to an intensive care unit (ICU), when compared with general hospitalized older adults, are especially inactive during hospitalization.[1] Although inactivity and immobility are detrimental to all hospitalized older adults, older ICU survivors differ greatly from general hospitalized older adults in severity of illness, comorbidity, and intensity of treatment.

Moreover, older ICU survivors often experience life-changing symptoms, including new or worsening cognitive dysfunction, physical impairment, and/or psychological distress, which are recognized as components of post–intensive care syndrome.[2] Survivors of the ICU experience a wide range of long-term symptoms related to post–intensive care syndrome, with some impairments persisting for up to 5 to 15 years.[3] Symptoms of post–intensive care syndrome are prevalent and can overlap; in fact, about 64% and 56% of ICU survivors report one or more symptoms at 3 months and 12 months after discharge, respectively.[4] Close to two-thirds of ICU survivors experience clinically meaningful cognitive impairment.[5] About 40% of ICU survivors may experience physical impairments or weakness 1 year after leaving the ICU.[6] Regarding psychological distress, about half of ICU survivors report psychological symptoms of anxiety, depression, or posttraumatic stress disorder at 3 and 12 months after ICU discharge.[7]

Older adults admitted to an ICU are especially inactive throughout hospitalization.

Associations between hourly activity counts and symptoms of post–intensive care syndrome in older ICU survivors remain unclear. Thus, the aim of the present study was to explore the trends between hourly activity counts and symptoms of post–intensive care syndrome (cognitive dysfunction, physical impairment, and psychological distress) among hospitalized older ICU survivors in the early post-ICU transition period. We hypothesized that lower hourly activity counts would identify older ICU survivors who scored worse on the subdomains of post–intensive care syndrome.

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Methods

Design, Sample, and Setting

We analyzed pooled secondary data from 2 primary, prospective, cross-sectional studies of older ICU survivors. Before study initiation, we obtained study approval from the universities and their affiliated hospital institutional review boards. Participants signed written informed consent forms in either English or Spanish. A total of 49 English- or Spanish-speaking hospitalized older ICU survivors (ages 65 and older), who were functionally independent before hospital admission and who required mechanical ventilation while in the ICU, were enrolled in our 2 studies. Study recruitment took place at 2 academic medical centers in south Florida between 2017 and 2021. After patients were discharged, we recruited a convenience sample of older ICU survivors from all post-ICU medical-surgical units, also referred to as hospital ward units, regardless of admission diagnosis or type of ICU. Participants were enrolled within 24 to 48 hours of ICU discharge.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) functional independence on activities of daily living (ADLs) before hospital admission (Katz Index=6); (2) received mechanical ventilation while in the ICU; and (3) preferred language or fluency in either English or Spanish. The Katz Index of Activities of Daily Living (Katz Index) was used to assess the participants' baseline functional ability (ie, before hospital admission) to independently perform 6 ADLs: bathing, dressing, toileting, transferring, continence, and feeding.[8] As done in previous studies, during recruitment, potential participants were requested to self-report their

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baseline ability to perform each ADL 2 weeks before hospital admission.[9] The Katz Index has demonstrated high reliability, with Cronbach α coefficients ranging between 0.87 and 0.94.[10] Potential participants who scored less than 6 on the Katz Index were deemed ineligible; the maximum score of 6 indicates functional independence on ADLs without any supervision or assistance. Related clinical documentation (eg, physical therapy, social work) was also reviewed to assess the participants' baseline functional ability.

Exclusion criteria were as follows: (1) documented preexisting diagnosis of mild cognitive impairment or dementia; (2) documented sleep disorder (not including obstructive sleep apnea); (3) active palliative care or hospice orders; (4) history of psychiatric disorder; (5) history of spinal cord injury; and (6) admitted from a long-term care facility, assisted living facility, or skilled nursing or rehabilitation facility or receiving private nursing care for ADLs at home.

Measures

Sample Characteristics. Demographic characteristics were obtained from participants through face-to-face interviews and from their electronic health records. Clinical characteristics were collected from the participants' electronic health records; these included admission diagnoses, ICU severity of illness, ICU length of stay, length of mechanical ventilation, and length of hospitalization.

Post-ICU Hourly Activity. Wrist actigraphy (Actiwatch Spectrum; Philips Respironics) was used to collect data on early post-ICU hourly activity, beginning at the time of study enrollment. An actigraph is a wrist-worn monitoring device that measures gross motor activity. Actigraphy uses accelerometry algorithms generated from activity counts to measure activity and rest patterns in hospitalized older inpatients[11] and adult ICU patients.[12] Activity counts were automatically calculated in 15-second epochs. Hourly activity counts can range widely between levels of activity. For example, activity thresholds among healthy adults for routine activities are as follows: sleeping, 600 activity counts/h; resting or lying down awake, 1140 activity counts/h; sitting and watching television, 4020 activity counts/h; sitting and eating, 10 620 activity counts/h; sitting with active arm movements, 11 400 activity counts/h; and casual walking, 14 700 activity counts/h.[13] With regard to older adults, sedentary activity has been established in the literature as less than 6000 activity counts/h.[14] The present analyses included hourly activity counts for a full 24-hour period to capture activity counts at the early transition period out of the ICU. We chose a 24-hour activity observation period because most higher-functioning ICU survivors were discharged from the hospital within 2 days of ICU discharge. Daytime activity was defined as activity counts between 6:00 AM and 9:59 PM, and nighttime activity was defined as activity counts between 10:00 PM and 5:59 AM. Ideally, healthy older adults should display higher activity counts during daytime hours (ie, awake and active) and lower activity counts during nighttime hours (ie, asleep and inactive).[15] Mean hourly activity counts were calculated for each hour across all participants.

Post-ICU Cognitive Dysfunction. Selected assessments from the National Institutes of Health (NIH) Toolbox Cognition Battery[16] were used to evaluate 2 subdomains of cognitive dysfunction: visuospatial inhibitory attention and cognitive flexibility.[17] The Flanker Inhibitory Control and Attention Test (FICAT) measures visuospatial attention, which represents the ability to focus, sustain, and shift attention. The Dimensional Change Card Sort Test (DCCST) measures cognitive flexibility, which represents the ability to shift responses between tasks. Both the FICAT and the DCCST assess subdomains of executive function, which is indicative of higher cognitive capacity and functional status among older adults. Research staff conducted both assessments within the participant's hospital room during an uninterrupted session on the day after study enrollment. Analyses of the FICAT and DCCST used fully corrected T scores (adjusted for age, sex, race/ethnicity, and level of education), where a score of 50 represents the population mean and 10 is the SD. Higher scores indicate better cognitive performance.

> Hourly activity counts between 12:00 AM and 11:59 PM were recorded for a full 24-hour period to illustrate activity patterns at the early transition period out of the intensive care unit.

Post-ICU Physical Impairment. Selected assessments from the NIH Toolbox Motor Battery[18] were used to evaluate 2 domains of physical impairment: grip strength and dexterity. The Grip Strength Test (GST) assesses dominant hand grip strength via handgrip dynamometry.[18] Grip strength is a feasible measure of ICU-acquired weakness.[19] The 9-Hole Pegboard Dexterity Test (PDT) assesses dominant hand dexterity using a pegboard task.[20] Research staff conducted these assessments within the participant's hospital room on the day after study enrollment. Analyses of the GST and the PDT used fully corrected T scores (adjusted for age, sex, race/ethnicity, and level of

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Table 1
Demographic, clinical, and post–intensive care syndrome characteristics (N=49)

Characteristic	Value
Age, mean (SD), y	72.9 (5.9)
Male, No. (%) of patients	33 (67)
Race/ethnicity, self-reported, No. (%) of patients	
White, not Hispanic/Latino	40 (82)
Black/African American, not Hispanic/Latino	8 (16)
Asian or Pacific Islander, not Hispanic/Latino	1 (2)
Hispanic/Latino	9 (18)
Primary ICU admission, No. (%) of patients	
Cardiovascular	22 (45)
Medical	16 (33)
Surgical	6 (12)
Neuroscience	3 (6)
Trauma	2 (4)
APACHE III score, mean (SD) (range 0-299)	81.5 (31.9)
Length of ICU stay, mean (SD), d	8.4 (10.2)
Duration of mechanical ventilation, mean (SD), d	3.7 (6.4)
NIH Toolbox[a] Cognition Battery Assessments, mean (SD) (range 0-100)	
FICAT score[b] (visuospatial attention)	33.0 (7.7)
DCCST score[c] (cognitive flexibility)	41.2 (8.6)
NIH Toolbox[a] Motor Battery Assessments, mean (SD) (range 0-100)	
GST score[d] (grip strength)	37.5 (13.9)
PDT score[e] (dexterity)	33.2 (9.6)
PROMIS Emotion Instruments,[a] mean (SD) (range 0-100)	
EDD score[f] (depression)	52.8 (10.4)
EDA score[g] (anxiety)	57.8 (10.9)
Post-ICU hourly activity counts,[h] mean (SD)	2401 (793)

Abbreviations: APACHE, Acute Physiology, Age, Chronic Health Evaluation; DCCST, Dimensional Change Card Sort Test; EDA, Emotional Distress–Anxiety Short Form 8a; EDD, Emotional Distress–Depression Short Form 8a; FICAT, Flanker Inhibitory Control and Attention Test; GST, Grip Strength Test; ICU, intensive care unit; NIH, National Institutes of Health; PDT, 9-Hole Pegboard Dexterity Test; PROMIS, Patient-Reported Outcomes Measurement Information System.

[a] Analyses used fully corrected T scores (adjusted for age, sex, race/ethnicity, and level of education), where a score of 50 represents the population mean and 10 is the SD.
[b] Higher scores indicate better cognitive performance related to visuospatial attention.
[c] Higher scores indicate better cognitive performance related to cognitive flexibility.
[d] Higher scores indicate better physical performance related to dominant hand grip strength.
[e] Higher scores indicate better physical performance related to dominant hand dexterity.
[f] Higher scores indicate worse severity of depression.
[g] Higher scores indicate worse severity of anxiety.
[h] Mean activity counts per hour during the 24-hour period.

education), where a score of 50 represents the population mean and 10 is the SD. Higher scores indicate better physical performance.

Post-ICU Psychological Distress. Selected instruments from the Patient-Reported Outcomes Measurement Information System (PROMIS)[21] were used to evaluate 2 domains of psychological distress: depression and anxiety. The Emotional Distress–Depression Short Form 8a (EDD) was used to assess depression.[22] The Emotional Distress–Anxiety Short Form 8a (EDA) was used to assess anxiety.[22] Research staff administered these 2 instruments via interview in the participant's hospital room on the day after study enrollment. Analyses used fully corrected T scores (adjusted for age, sex, race/ethnicity, and level of education), where a score of 50 represents the population mean and 10 is the SD. Higher scores indicated worse symptom severity.

Data Analyses

Preliminary descriptive analyses were conducted using IBM SPSS Statistics version 26. Before analyses, the data were examined for distribution shape, missing data, and outliers. For each post–intensive care syndrome outcome measure (post-ICU cognitive dysfunction, physical impairment, and psychological distress), scores were divided into 2 groups: scores that were within or better than 1 SD of the mean and scores that were worse than 1 SD of the mean. Hourly activity counts were then averaged within the 2 groups.

Results

Descriptive Analyses

Table 1 reports demographic and clinical characteristics of the study sample, as well as descriptive statistics and group means for each post–intensive care syndrome outcome measure. Table 2 summarizes hourly activity counts by scores on each subdomain of post–intensive care syndrome. The Figure illustrates a time series of 24-hour activity counts by scores on each outcome measure.

Inactivity and Subdomains of Post–Intensive Care Syndrome

As shown by the shape of the distribution (see Figure), hourly activity counts tended to be lower among older ICU survivors who scored worse than 1 SD below the mean on the cognitive dysfunction and physical impairment assessments (T scores less than 40 on the FICAT, DCCST, GST, and PDT), when compared with hourly activity counts among those who scored within or better than 1 SD of the mean (T score greater than 40). Those who scored better on cognitive dysfunction and physical impairment assessments also tended to be more active during daytime hours and less active during nighttime hours. Hourly activity counts also tended to be lower among older ICU survivors who scored worse than 1 SD above the mean on the psychological distress instruments (T score greater than 60 on the EDD and EDA), when compared with hourly activity counts among those

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Table 2
Hourly activity counts by post–intensive care syndrome assessment scores

NIH Toolbox or PROMIS score[a]	Hourly activity counts,[b] mean (SD)		
	Overall	Daytime[c]	Nighttime[d]
FICATT score[e] (visuospatial attention)			
Worse than 1 SD below the mean (n = 38)	2364 (718)	2705 (599)	1681 (354)
Within 1 SD of the mean (n = 8)	2562 (1481)	3163 (1358)	1361 (882)
DCCSTT score[f] (cognitive flexibility)			
Worse than 1 SD below the mean (n = 19)	2399 (584)	2598 (551)	2001 (448)
Within 1 SD of the mean (n = 26)	2464 (1043)	2995 (793)	1401 (525)
GSTT score[g] (grip strength)			
Worse than 1 SD below the mean (n = 27)	2073 (517)	2302 (441)	1616 (323)
Within 1 SD of the mean (n = 21)	3710 (1189)	3288 (923)	1555 (729)
PDTT score[h] (dexterity)			
Worse than 1 SD below the mean (n = 32)	2358 (700)	2670 (588)	1733 (448)
Within 1 SD of the mean (n = 13)	2647 (1179)	3221 (963)	1499 (568)
EDDT score[i] (depression)			
Worse than 1 SD above the mean (n = 13)	2104 (503)	2198 (379)	1917 (682)
Within 1 SD of the mean (n = 36)	2524 (913)	2981 (685)	1610 (550)
EDAT score[j] (anxiety)			
Worse than 1 SD above the mean (n = 22)	2352 (561)	2549 (485)	1960 (515)
Within 1 SD of the mean (n = 27)	2442 (994)	2930 (758)	1466 (619)

Abbreviations: DCCST, Dimensional Change Card Sort Test; EDA, Emotional Distress–Anxiety Short Form 8a; EDD, Emotional Distress–Depression Short Form 8a; FICAT, Flanker Inhibitory Control and Attention Test; GST, Grip Strength Test; NIH, National Institutes of Health; PDT, 9-Hole Pegboard Dexterity Test; PROMIS, Patient-Reported Outcomes Measurement Information System.

[a] Analyses used fully corrected T scores (adjusted for age, sex, race/ethnicity, and level of education), where a score of 50 represents the population mean and 10 is the SD.
[b] Mean activity counts during a 24-hour period, measured by wrist actigraphy.
[c] Daytime activity, defined as mean hourly activity counts between 6:00 AM and 9:59 PM, measured by wrist actigraphy.
[d] Nighttime activity, defined as mean hourly activity counts between 10 PM and 5:59 AM, measured by wrist actigraphy.
[e] Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better cognitive performance related to attention.
[f] Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better cognitive performance related to cognitive flexibility.
[g] Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better physical performance related to dominant hand grip strength.
[h] Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better physical performance related to dominant hand dexterity.
[i] Worse than 1 SD above the mean = T score greater than 60; within 1 SD of the mean = T score less than 60. Higher scores indicate worse severity of depression.
[j] Worse than 1 SD above the mean = T score greater than 60; within 1 SD of the mean = T score less than 60. Higher scores indicate worse severity of anxiety.

who scored within or better than 1 SD of the mean (T score less than 60). Those who reported less severe symptom burden on the psychological distress instruments also tended to be more active during daytime hours and less active during nighttime hours.

Discussion

The results of our study suggest that post-ICU inactivity may signal early symptoms of post–intensive care syndrome. We found that post-ICU hourly activity counts were higher in ICU survivors with better performance on visuospatial attention, cognitive flexibility, grip strength, and dexterity. Post-ICU hourly activity counts were also higher in ICU survivors with less severe scores for depression and anxiety. We also found that hourly activity counts for older ICU survivors fell far below those of even sedentary older adults. Hourly activity counts among our participants were above activity levels observed for sedentary older adults when resting or lying down, but below those observed for sedentary older adults when sitting and watching television. Of note, an inclusion criterion for our study was functional independence before hospital admission, which implies that the post-ICU impairments in cognitive and physical function in these older ICU survivors were perhaps new deficits associated with their critical illness. We suggest that post-ICU activity may identify older adults at risk of developing the functional impairments and psychological distress observed in post–intensive care syndrome.

The hourly activity counts among our study participants provide additional evidence that the needs of older ICU survivors differ from those of older

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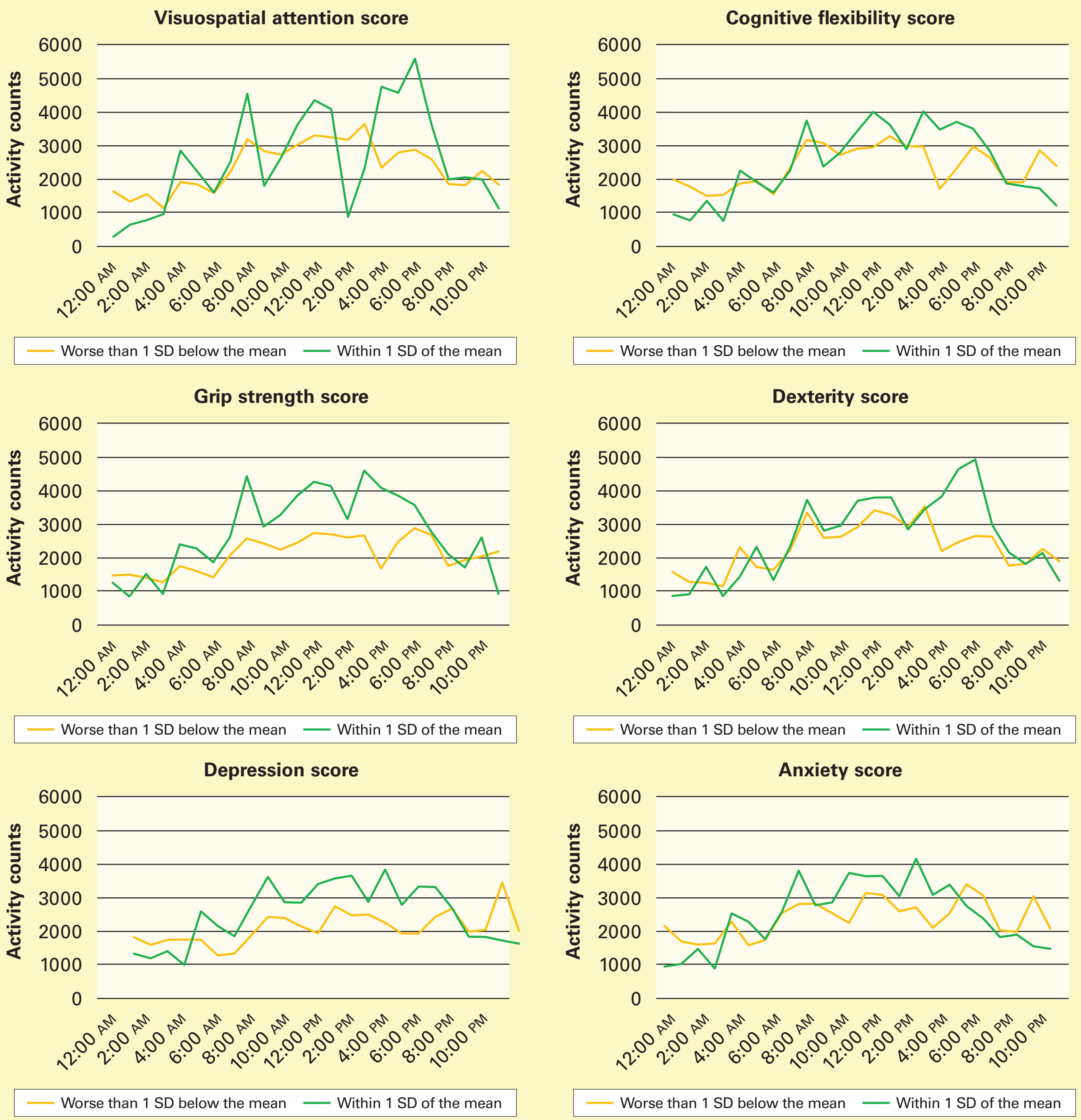

Figure Twenty-four hours of hourly activity counts by scores on each outcome measure. *Visuospatial attention score*: National Institutes of Health (NIH) Toolbox Cognition Battery Flanker Inhibitory Control and Attention Test fully corrected T score. Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better cognitive performance related to attention. *Cognitive flexibility score*: NIH Toolbox Cognition Battery Dimensional Change Card Sort Test fully corrected T score. Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better cognitive performance related to cognitive flexibility. *Grip strength score*: NIH Toolbox Motor Battery Grip Strength Test fully corrected T score. Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better physical performance related to dominant hand grip strength. *Dexterity score*: NIH Toolbox Motor Battery 9-Hole Pegboard Dexterity Test fully corrected T score. Worse than 1 SD below the mean = T score less than 40; within 1 SD of the mean = T score greater than 40. Higher scores indicate better physical performance related to dominant hand dexterity. *Depression score*: PROMIS Emotional Distress–Depression Short Form 8a. Worse than 1 SD above the mean = T score greater than 60; within 1 SD of the mean = T score less than 60. Higher scores indicate worse seve rity of depression. *Anxiety score*: PROMIS Emotional Distress–Anxiety Short Form 8a. Worse than 1 SD above the mean = T score greater than 60; within 1 SD of the mean = T score less than 60. Higher scores indicate worse severity of anxiety. *Hourly activity counts*: Mean activity counts averaged hourly during a 24-hour period as measured by wrist actigraphy. Higher activity counts indicate greater activity.

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general medicine inpatients who were not admitted to intensive care. Specifically, the mean hourly activity in our study was 2401 (SD, 793) activity counts/h; in comparison, Beveridge et al[13] reported a mean daytime activity of 4620 activity counts/h, and Kessler et al[23] reported a mean daytime activity of 7740 activity counts/h. Moreover, in those 2 studies, adults ages 50 and older were enrolled and patients transferred from the ICU or those who were hospitalized for more than 72 hours before enrollment were excluded. In contrast, in our study, we report hourly activity counts from a sample of older adults ages 65 and older who received mechanical ventilation in the ICU and who were hospitalized for about 2 weeks, on average, before study enrollment. In our study, we examined hourly activity counts specifically among older ICU survivors, because older adults have the highest age-specific incidence of mechanical ventilation.[24] In addition, more than half of the patients in our sample were admitted to a surgical or trauma ICU for major surgery, which often necessitated the administration of pain-relieving medications such as opioids during our activity observation period. These findings highlight the prevalence of inactivity among older ICU survivors and their unique risk factors.

Cognitive impairment is often severe among ICU survivors. To elaborate, 40% of ICU survivors have global cognition scores that are similar in severity to those typically observed in moderate traumatic brain injury, and 26% of ICU survivors have scores that are observed in mild Alzheimer disease.[25] If this prevalence of cognitive impairment has been observed in ICU survivors of all ages, it is likely that cognitive impairment is more prevalent in older ICU survivors. Indeed, the mean fully corrected T scores on both visuospatial attention and cognitive flexibility in our study were about 1 to 2 SDs below population means (Table 1). Deficits in executive function, the subdomain of cognition responsible for inhibitory control/attention and cognitive flexibility, are associated with admission to a skilled nursing facility.[26] The present study reports graphic trends between higher hourly activity counts and better performance on measures of executive function (see Figure). Participants who scored worse on these executive function measures also tended to display higher nighttime activity levels, indicating worse or fragmented nighttime sleep (Table 2). To elaborate, nighttime hourly activity counts were slightly higher among participants who scored worse than 1 SD of the mean on visuospatial attention and cognitive flexibility (1681 [SD, 354] activity counts/h and 2001 [SD, 448] activity counts/h, respectively), compared with participants who scored within or better than 1 SD of the mean (1361 [SD, 882] activity counts/h and 1401 [SD, 525] activity counts/h, respectively). We suggest that lower daytime activity levels (ie, greater daytime sleep) and higher nighttime activity levels (ie, less nighttime sleep) could alert health care providers in the early post-ICU transition period to patients who may be at highest risk for cognitive dysfunction associated with sleep and circadian rhythm disruption, delirium, and post–intensive care syndrome. Researchers may be able to use activity data to identify older patients who may benefit the most from intervention studies with primary outcomes related to cognitive function.

Recovery of physical function is clinically important for older ICU survivors. Recent studies have shown that, among general hospitalized older adults, low activity levels within the hospital may be predictive of hospital-acquired disability—but these studies also excluded older adults who were admitted to an ICU.[27,28] Admission to the ICU with mechanical ventilation is predictive of poor motor outcomes,[19] and older adults who receive mechanical ventilation are at higher risk of physical disability than are those who do not.[29] The older ICU survivors in this study demonstrated noteworthy physical weakness: fully corrected T scores on both grip strength and dexterity were significantly below the population means (Table 1). There was a trend between high scores on these 2 physical function measures and greater activity during daytime hours (see Figure). For example, daytime hourly activity counts were considerably lower among participants who scored worse than 1 SD of the mean on grip strength and dexterity (2302 [SD, 441] activity counts/h and 2670 [SD, 588] activity counts/h, respectively), compared with participants who scored within 1 SD of the mean (3288 [923] activity counts/h and 3221 [963] activity counts/h, respectively); refer to Table 2 for details. Further, nighttime sleep loss (ie, increased activity during nighttime hours) may contribute to significant reductions in daytime activity levels and strength or physical function, which may affect functional recovery from critical illness.[30] Hourly activity levels in the early post-ICU transition period may suggest the potential development of physical impairments

Older ICU survivors who scored better on cognitive dysfunction and physical impairment assessments also tended to be more active during daytime hours and less active during nighttime hours.

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seen in post–intensive care syndrome. Future research could use activity data to identify the best time of day to target interventions designed to improve physical and motor function.

Psychological sequelae of critical illness, such as new or increased severity of depression, anxiety, or posttraumatic stress disorder, are notable components of post–intensive care syndrome. Significant risk factors for psychological distress in ICU survivors include female sex, history of mental health disorder, and negative ICU experience; older age is also a risk factor for depression and anxiety in ICU survivors.[31] However, little is known regarding the association between physical activity and development of psychological distress in ICU survivors in the early transition out of ICU. A previous systematic review found that physical activity improved outcomes related to psychological sequelae, but the included studies were not powered for statistical significance and measured psychological outcomes 3 months or longer after hospital discharge.[32] In the present study, those who had lower daytime activity and higher nighttime activity (Table 2) also had worse EDD and EDA scores, indicating more psychological distress. As an example, daytime hourly activity counts were lower among participants who scored worse than 1 SD of the mean on depression and anxiety (2198 [SD, 379] activity counts/h and 2549 [SD, 485] activity counts/h, respectively), compared with participants who scored within or better than 1 SD of the mean (2981 [SD, 685] activity counts/h and 2930 [SD, 758] activity counts/h, respectively). However, these differences did not reach statistical significance. Future studies with larger sample sizes should evaluate whether there is a temporal association between physical activity and lower psychological distress.

Patterns of lower daytime activity (ie, greater daytime sleep) and higher nighttime activity (ie, less nighttime sleep) could alert health care providers in the early post-ICU transition period to patients who may be at risk for cognitive dysfunction associated with post–intensive care syndrome.

The graphic trends presented in the Figure and the scores listed in Table 2 also suggest that the differences in hourly activity by symptoms of post–intensive care syndrome were more prominent during daytime hours than during nighttime hours. For example, hourly activity counts were higher during daytime hours and lower during nighttime hours among those who scored better on each subdomain (Table 2). Our time-based differences in activity patterns echo those found by Lim et al, who observed intraday variations in activity among general hospitalized older adults, with peak activity occurring between 9 AM and 11 AM and between 6 PM and 7 PM.[33] Our study shows hourly variations in activity among a sample of older ICU survivors recently transferred out of intensive care, which may be relevant to implementation of future research interventions. If lower-functioning ICU survivors are more sedentary during certain daytime hours, then future studies could implement interventions during these hours. We also recommend that future intervention studies examine the impact of increased daytime activity and promotion of nighttime sleep on cognitive, physical, and psychological symptoms associated with post–intensive care syndrome.

Limitations of our study include the short observation period and small sample size; these were due to the exploratory study design. Limitations also include exclusion of participants who did not speak either English or Spanish. Our preliminary analyses are exploratory and do not imply causality between post-ICU hourly activity and performance on physical and cognitive assessments or symptom burden related to depression and anxiety. Interpretations should be made cautiously. Delirium may also affect activity and cognition in older ICU survivors. Our protocol included reviewing provider documentation of ICU delirium; however, clinical documentation of delirium in older ICU patients is unreliable for use in research studies.[34] We did not review durations of physical or occupational therapy sessions; however, prior research has shown that, despite receiving rehabilitation throughout recovery on the medical/surgical wards after ICU discharge, ICU survivors are physically active only about 5% of the day during hospitalization.[35] Future research should include extended periods of actigraphy or longitudinal follow-up to observe long-term trends in activity and outcomes related to post–intensive care syndrome.

Conclusion

Older ICU survivors who are profoundly inactive during daytime hours, despite transition of care out of the ICU, may be at highest risk for functional impairments and symptom burden associated with post–intensive care syndrome. Lower post-ICU activity could be used to identify older ICU survivors who are likely to perform worse on assessments of

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cognitive and physical function and experience greater psychological distress; further studies are required to determine which groups may benefit the most from targeted interventions. Studies are also needed to determine whether increasing daytime activity could have an impact on post–intensive care syndrome. Personalized interventions for older adults based on their level of function are needed and perhaps should target certain daytime hours when sedentary activity or inactivity is more likely to occur. Ultimately, these findings may guide future research interventions to promote activity and possibly mitigate functional impairments and symptom burden associated with post–intensive care syndrome.

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CE 1.0 Hour Category B

Notice to CE enrollees:

This article has been designated for CE contact hour(s). The evaluation demonstrates your knowledge of the following objectives:

1. Define post–intensive care syndrome and its associated subdomains and symptoms.
2. Identify risk factors for post–intensive care syndrome among older adults recovering from critical illness.
3. Describe intradaily patterns of inactivity that may signal increased risk for developing post–intensive care syndrome.

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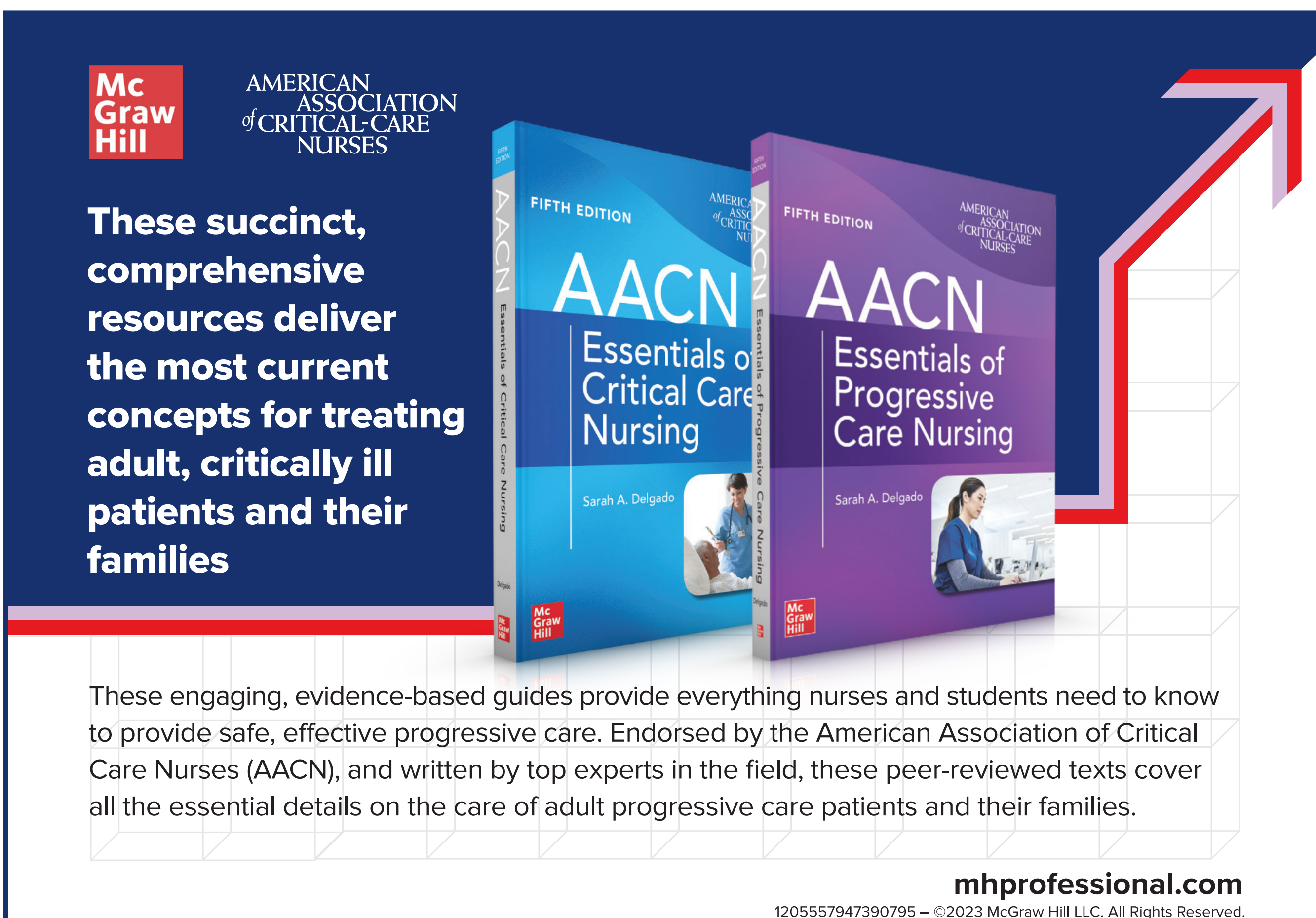

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