NCPD Nursing Continuing Professional Development

Graphic Representation of Hourly Activity Counts May Identify Discharge Outcomes for Older Adults After Critical Illness

Maya N. Elías, PhD, RN, Cindy L. Munro, PhD, RN, ANP-BC, FAANP, FAAAS, FAAN & Zhan Liang, PhD, RN

Abstract

Purpose: After transitioning from an intensive care unit (ICU), hospitalized older adults are inactive, which may affect discharge outcomes. We examined trends between post-ICU hourly activity counts and discharge disposition among hospitalized older ICU survivors.

Design: A prospective, exploratory research design was used in this study.

Methods: We enrolled older ICU survivors within 24–48 hours of ICU discharge. Actigraphy measured post-ICU hourly activity counts (0:00 a.m.–23:59 p.m.). Chart review provided discharge disposition. Analyses were conducted to illustrate trends between post-ICU hourly activity counts and discharge disposition.

Findings: Mean hourly activity was about 2,233 ± 569 counts/hour. Graphs revealed trends between hourly activity counts and discharge disposition. Participants with lower post-ICU activity counts, especially during daytime hours, tended to be discharged to a care facility.

Conclusions: Future nursing research should determine whether post-ICU inactivity during hospitalization is a modifiable risk factor for worse discharge outcomes.

Clinical Relevance: Activity could be a prognostic indicator of discharge disposition for older ICU survivors.

Keywords: Older adults; activity; critical illness; discharge outcomes; post-intensive care syndrome; hospitalization.

Introduction

Inactivity and poor mobility among hospitalized older adults have been previously described in the literature as an epidemic (Brown et al., 2009), which has prompted the development of clinical practice guidelines on activity for older adults during hospitalization for acute medical illness (Baldwin et al., 2020). In fact, during hospitalization for acute medical illness, about 16%–33% of older adults exhibit low or intermediate levels of physical activity. Low mobility is a predictor of functional decline, new institutionalization, and mortality (Brown et al., 2004). Yet, for older adults recovering from critical illness and hospitalization in the intensive care unit (ICU), there has been little research or guidance on recovery and rehabilitation specifically addressing post-ICU inactivity.

Although studies examining activity levels have been conducted in general hospitalized older patients, few studies have focused on older ICU survivors and their outcomes. To our knowledge, studies have not yet examined the association between hourly activity and hospital discharge outcomes among older ICU survivors. One study reported an association between lower physical activity levels and worse discharge outcomes (i.e., inability to return home at time of discharge) among general hospitalized older inpatients (Tasheva et al., 2020); however, the study did not focus on older adults who required ICU-level care and/or mechanical ventilation. It is known that older age and mechanical ventilation are risk factors associated with discharge to a facility (e.g., acute inpatient rehabilitation, skilled nursing facility, long-term acute care hospital) after ICU hospitalization (Feng et al., 2009; Gehlbach et al., 2011). The aim of this study was to explore the relationships between early post-ICU hourly activity counts and discharge disposition among

Correspondence: *Maya N. Elías, PhD, RN, University of Miami School of Nursing and Health Studies, 5030 Brunson Drive, Ste 423, Coral Gables, FL 33146. E-mail: mxe513@miami.edu*

The study protocol was approved by the institutional review boards of the university and affiliated medical center.

University of Miami School of Nursing and Health Studies, Coral Gables, FL, USA

Cite this article as:
Elías, M. N., Munro, C. L., & Liang, Z. (2021). Graphic representation of hourly activity counts may identify discharge outcomes for older adults after critical illness. *Rehabilitation Nursing, 46*(5), 247–252. doi: 10.1097/rnj.0000000000000312

a cohort of hospitalized older ICU survivors. We hypothesized that post-ICU hourly activity counts would tend to be lower among older ICU survivors who were eventually discharged to a care facility. If so, then differences in post-ICU hourly activity counts could potentially help rehabilitation nurses identify at-risk older ICU survivors who may be likely to be discharged to a care facility rather than home.

Methods

Sample and Setting

We enrolled 30 hospitalized older adults (ages 65 years and older) who were recently transferred out of ICU (within 24–48 hours of ICU discharge), mechanically ventilated while in ICU, and functionally independent prior to hospitalization. Using an exploratory study design and convenience sampling, we recruited patients from all 12 medical-surgical units at a Level 1 trauma hospital. The institutional review boards of the university and the affiliated Level 1 trauma hospital approved the protocol prior to study initiation.

Inclusion and Exclusion Criteria

All study participants must have been community-dwelling older adults (i.e., admitted from home) and functionally independent prior to hospital admission. The Katz Index of Activities of Daily Living assessed the subject's baseline functional ability (i.e., prior to their hospital admission) to independently perform six activities of daily living: bathing, dressing, toileting, transferring, continence, and feeding (Katz et al., 1963). During recruitment, potential study participants were asked to retrospectively comment on their baseline ability to perform each of these activities of daily living independently 2 weeks prior to hospital admission (Covinsky et al., 2000). The Katz Index of Activities of Daily Living has demonstrated high reliability, with Cronbach's alpha coefficients ranging from .87 to .94 (Wallace & Shelkey, 2008). A score of 6 out of 6 indicates functional independence without any supervision or assistance; therefore, potential participants who scored less than 6 were ineligible for the study. Additional exclusion criteria included preexisting diagnosis of mild cognitive impairment or dementia, history of psychiatric disorder, active palliative care or hospice orders, and/or spinal cord injury. Patients admitted from a care facility or those who received home health care at home prior to admission were excluded from this study.

Measures

Data Collection and Sample Characteristics

Demographic data were collected from participants and their electronic medical records. Relevant data included admission diagnoses, ICU severity of illness (Acute Physiology, Age, Chronic Health Evaluation III score [APACHE]; Knaus et al., 1991), ICU length of stay and readmissions, length of mechanical ventilation while in ICU, and administrations of opioids and/or benzodiazepines during the observation period of actigraphy.

Post-ICU Activity

Wrist actigraphy (Actiwatch Spectrum, Philips Respironics) collected data on early post-ICU hourly activity, beginning at the time of study enrollment. An actigraph is a lightweight, wrist-worn monitoring device, designed for measurement of gross motor activity. Actigraphy, based on accelerometry algorithms using activity counts, has been utilized to measure activity patterns in hospitalized older inpatients (Lim et al., 2018) and adult ICU patients (Schwab et al., 2019). An actigraph was placed on each participant's dominant arm. Activity counts were generated for each 15-second epoch: Activity counts that fell below a preset threshold designated as "wake" were automatically scored as rest or sleep. Analyses included hourly activity counts between 0:00 a.m. to 23:59 p.m. during a full 24-hour period after study enrollment. Hourly activity count thresholds are discussed in the literature: sleeping (600 activity counts/hour), resting or lying down awake (1,140 activity counts/hour), sitting and watching television (4,020 activity counts/hour), sitting and eating (10,620 activity counts/hour), sitting with active arm movement such as writing a letter (11,400 activity counts/hour), casual walking (14,700 activity counts/hour), and brisk walking (21,180 activity counts/hour; Beveridge et al., 2015). Sedentary behavior, specifically in older adults, has been defined as less than 6,000 activity counts/hour (Evenson et al., 2012).

Discharge Outcomes

Discharge disposition to home (i.e., home with minimal assistance or home with home health care) versus discharge to a facility (i.e., inpatient rehabilitation facility, skilled nursing facility, or long-term acute care hospital) was prospectively collected via electronic medical records.

Data Analyses

Preliminary descriptive analyses were conducted using IBM SPSS Statistics Version 26. The data were also examined for distribution shape, missing data, and outliers prior to analyses. Preliminary trends were visually depicted by graphs of aggregate activity (hourly activity counts over a 24-hour period) grouped by discharge outcome. Graphs were produced in Microsoft Excel and are presented in Figure 1.

Results

Sample Characteristics

Table 1 summarizes the demographic and clinical characteristics of the study sample. Two participants were transferred to out-of-network hospitals, so discharge disposition data for these two participants were unavailable/missing for further analyses. Post-ICU hourly activity averaged 2,233 ± 569 activity counts/hour among the final 28 participants. Three (10%) participants were readmitted to ICU after the actigraphy observation period. Ten (33.3%) participants were discharged home, whereas 5 (16.7%) were discharged to inpatient rehabilitation facilities, 12 (40%) were discharged to skilled nursing facilities, and 1 was discharged (3.3%) to a long-term acute care hospital.

Post-ICU Activity and Discharge Disposition

Post-ICU hourly activity counts tended to be higher among participants eventually discharged home (2,862 ± 908 activity counts/hour) when compared to those discharged to an inpatient rehabilitation facility (2,062 ± 933 activity counts/hour), a skilled nursing facility (1,901 ± 500 activity counts/hour), and a long-term acute care hospital (478 ± 444 activity counts/hour). In addition, Figure 1 provides graphic representation of a 24-hour activity/rest cycle, including daytime and nighttime hours, and further illustrates the trends between post-ICU hourly activity counts and discharge disposition. Participants with lower post-ICU hourly activity counts, especially during morning and afternoon hours (Figure 1), tended to be discharged to a care facility instead of home.

Discussion

Greater post-ICU hourly activity may be associated with better hospital discharge outcomes, specifically discharge to home instead of to a care facility, based on preliminary findings from our study cohort of hospitalized older ICU survivors. This study suggests that post-ICU hourly activity

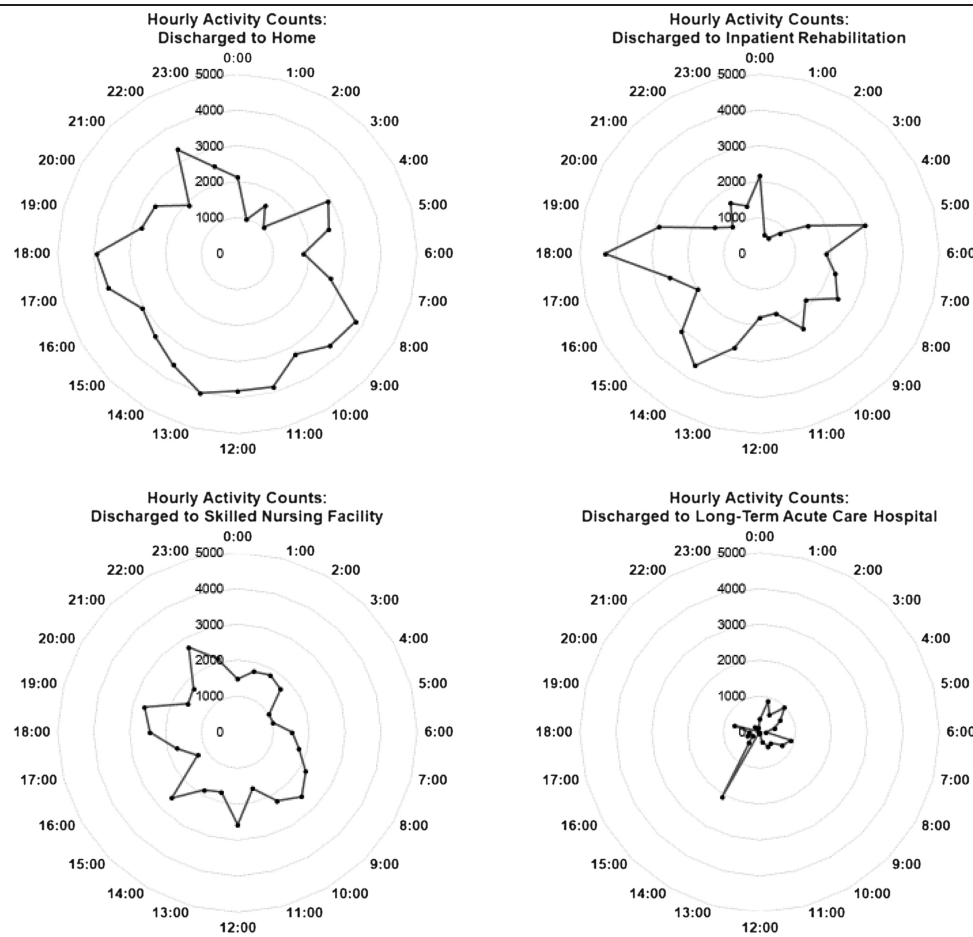

Figure 1. Graphic trends in post-intensive care unit (ICU) hourly activity counts by discharge disposition. These 24-hour radial graphs illustrate intradaily trends in post-ICU hourly activity counts (mean activity counts/hour) by disposition at time of hospital discharge. Notice that post-ICU hourly activity counts were visibly higher (especially during morning and afternoon hours) among the participants who were discharged home compared to the post-ICU hourly activity counts observed among the participants who were discharged to a care facility.

Table 1 Demographic and Clinical Characteristics

Variables	Mean ± *SD* or *n* (%)
Age, years	71.1 ± 4.6
Female	11 (39.3%)
Race/ethnicity	
White and non-Hispanic/Latino	21 (75%)
Black/African American	4 (14.3%)
Hispanic/Latino	3 (10.7%)
Primary ICU admission	
Medical	12 (42.9%)
Surgical, cardiovascular	10 (35.7%)
Surgical, transplant	2 (7.1%)
Trauma	2 (7.1%)
Neuroscience	2 (7.1%)
APACHE III score	94.8 ± 32.6
Length of ICU stay, days	11.9 ± 11.8
Length of mechanical ventilation, days	5.4 ± 7.6
Total length of hospital stay, days	24.3 ± 17.1
Post-ICU hourly activity counts	2233 ± 569
Discharge disposition	
Home	10 (35.7%)
Inpatient rehabilitation facility	5 (17.9%)
Skilled nursing facility	12 (42.9%)
Long-term acute care hospital	1 (3.6%)

Note. Values are mean ± standard deviation or *n* (%) of subjects. ICU = intensive care unit; APACHE = Acute Physiology, Age, Chronic Health Evaluation.

was lower among those who were eventually discharged to a facility. Importantly, we included only hospitalized older ICU survivors who, at baseline, were community-dwelling older adults and functionally independent prior to hospital admission, which strengthens the implications of the findings.

Hourly activity among the older ICU survivors in our study was significantly lower than that reported by other studies of hospitalized older adults (Beveridge et al., 2015; Kessler et al., 2019). Whereas Beveridge et al. (2015) reported a mean daytime activity of 77 activity counts/minute and Kessler et al. (2019) reported mean daytime activity of 129 activity counts/minute, the mean activity among the participants in this study was about 38 activity counts/minute. Of note, this sample was composed exclusively of older ICU survivors immediately following ICU discharge and who had been on mechanical ventilation, whereas these studies' samples were composed of hospitalized older adults who did not require intensive care. Another important distinction of this sample was the high proportion of participants who were admitted to a type of surgical or trauma ICU and/or underwent a major surgery during hospitalization. Thus, it is not surprising that about one fifth of our sample had received at least three or more doses of opioids for pain during the actigraphy observation period. Moreover, over half of our sample was discharged to a facility instead of home. The preliminary trends observed in our study support that hospitalized older adults who survive an ICU stay and mechanical ventilation continue to display sedentary behavior and inactivity even beyond the ICU setting and suggest that even activity during the early post-ICU transition period may affect discharge disposition.

The study results support those found in similar studies of hospitalized older adults. Objective measurement of activity using actigraphy or accelerometry has been associated with hospital-acquired disability (Pavon et al., 2020; Tasheva et al., 2020). These studies, however, did not exclusively focus on a cohort of hospitalized older ICU survivors and their unique discharge outcomes. In comparison to general hospitalized older inpatients, recovery in older ICU survivors is often complicated by higher severity of illness, and therefore, they are more likely to require prolonged inpatient stays and have higher acuity at discharge disposition. In fact, three participants were transferred back to ICU after completion of the actigraphy observation period, which prolonged their hospital stays. Up to 90% of older ICU survivors are discharged with at least one geriatric syndrome, which increases risk of new institutionalization in a care facility (Tang et al., 2016). Long-term cognitive, motor, and psychological sequelae resulting from critical illness are collectively recognized as post-ICU syndrome (Elliott et al., 2014). Because older adults are likely at highest risk of developing geriatric syndromes and/or post-ICU syndrome, rehabilitation nurses should pay particular attention to older ICU survivors throughout their recovery from critical illness.

The graphic analyses suggest that the differences in hourly activity by discharge disposition are more pronounced during daytime hours versus nighttime hours. Figure 1, created to display an activity/rest cycle in the form of a 24-hour clock, visually represents this comparison between daytime and nighttime hours. For instance, increased post-ICU hourly activity was observed during daytime hours, especially in the morning and afternoon, among those discharged home. In comparison, post-ICU hourly activity counts were lower during the morning and afternoon hours among those discharged to an inpatient rehabilitation facility, skilled nursing facility, or long-term acute care hospital. We suggest that routine nursing assessment of patients' activity levels during daytime hours could alert nurses and providers to potentially worse outcomes. It may be likely that older ICU survivors with higher severity of illness fall asleep between care activities (e.g., vital signs, medication administration, scheduled meal times, baths, nursing care, and rehabilitation therapy) and are therefore less active. Thus, we recommend that future nursing intervention studies incorporate promotion of daytime activity, combined with minimization of daytime sedentary behavior and/or daytime naps,

Key Practice Points

- Hospitalized older ICU survivors are profoundly inactive, especially during daytime hours, despite transition out of ICU.
- Lower levels of activity during daytime hours could identify older ICU survivors who are at risk of discharge to a care facility instead of home.
- Rehabilitation nurses could draw on their expertise to implement nursing interventions that decrease daytime sedentary behavior and immobility while simultaneously increasing daytime activity.
- Future research should investigate whether daytime activity could be a target for implementation of nursing interventions to promote outcomes for older ICU survivors.

to determine whether inactivity is a modifiable risk factor for worse discharge outcomes in older ICU survivors. We propose that perhaps promotion of daytime activity could mitigate worse discharge outcomes associated with critical illness hospitalization. Nursing interventions designed to avoid daytime naps and daytime sedentary behavior could be combined with other interventions to increase daytime activity.

Study limitations include the short observation period and small sample size; these are due to the exploratory study design. For example, we were unable to conduct a one-way analysis of variance to compare the difference in mean activity counts by discharge disposition because of the small sample size. Our preliminary analyses are exploratory, provide descriptive results as a pilot study, and thus do not imply causality between post-ICU hourly activity and discharge outcomes. Future research should include a larger sample size, with longer periods of actigraphy observation or longitudinal follow-up to observe trends in activity throughout recovery.

Conclusion

Hospitalized older adult survivors of critical illness are profoundly inactive despite transition of care out of ICU. Participants with lower post-ICU activity counts, especially during daytime hours, tended to be discharged to a care facility. Higher post-ICU daytime activity could help nurses identify older adults who are likely to be discharged home instead of a care facility. Increasing daytime activity may decrease healthcare costs associated with poor discharge outcomes for older ICU survivors, and rehabilitation nurses and family members alike could potentially aid recovery via optimization of the activity–rest cycle. Perhaps nursing assessment of patients' activity levels throughout recovery from critical illness could trigger the implementation of rehabilitative interventions to increase activity. Ultimately, these findings may reflect that daytime activity could be a target for future nursing research interventions to promote discharge outcomes for hospitalized older ICU survivors.

Conflict of Interest

The authors declare that there are no conflicts of interest.

Funding

The authors declare that there is no funding associated with this project.

References

Baldwin, C. E., Phillips, A. C., Edney, S. M., & Lewis, L. K. (2020). Recommendations for older adults' physical activity and sedentary behaviour during hospitalisation for acute medical illness: An international Delphi study. *International Journal of Behavioral Nutrition and Physical Activity*, *17*(1), 69. 10.1186/s12966-020-00970-3.

Beveridge, C., Knutson, K., Spampinato, L., Flores, A., Meltzer, D. O., Van Cauter, E., & Arora, V. M. (2015). Daytime physical activity and sleep in hospitalized older adults: Association with demographic characteristics and disease severity. *Journal of the American Geriatrics Society*, *63*(7), 1391–1400. 10.1111/jgs.13520.

Brown, C. J., Friedkin, R. J., & Inouye, S. K. (2004). Prevalence and outcomes of low mobility in hospitalized older patients. *Journal of the American Geriatrics Society*, *52*(8), 1263–1270. 10.1111/j.1532-5415.2004.52354.x.

Brown, C. J., Redden, D. T., Flood, K. L., & Allman, R. M. (2009). The underrecognized epidemic of low mobility during hospitalization of older adults. *Journal of the American Geriatrics Society*, *57*(9), 1660–1665. 10.1111/j.1532-5415.2009.02393.x.

Covinsky, K. E., Palmer, R. M., Counsell, S. R., Pine, Z. M., Walter, L. C., & Chren, M. M. (2000). Functional status before hospitalization in acutely ill older adults: Validity and clinical importance of retrospective reports. *Journal of the American Geriatrics Society*, *48*(2), 164–169. 10.1111/j.1532-5415.2000.tb03907.x.

Elliott, D., Davidson, J. E., Harvey, M. A., Bemis-Dougherty, A., Hopkins, R. O., Iwashyna, T. J., Wagner, J., Weinert, C., Wunsch, H., Bienveau, O. J., Black, G., Brady, S., Brodsky, M. B., Deutschman, C., Doepp, D., Flatley, C., Fosnight, S., Gittler, M., Gomez, B. T., & Needham, D. M. (2014). Exploring the scope of post-intensive care syndrome therapy and care: Engagement of non-critical care providers and survivors in a second stakeholders meeting. *Critical Care Medicine*, *42*(12), 2518–2526. 10.1097/ccm.0000000000000525.

Evenson, K. R., Buchner, D. M., & Morland, K. B. (2012). Objective measurement of physical activity and sedentary behavior among U.S. adults aged 60 years or older. *Preventing Chronic Disease*, *9*, E26–E26. 10.5888/pcd9.110109.

Feng, Y., Amoateng-Adjepong, Y., Kaufman, D., Gheorghe, C., & Manthous, C. A. (2009). Age, duration of mechanical ventilation, and outcomes of patients who are critically ill. *Chest*, *136*(3), 759–764. 10.1378/chest.09-0515.

Gehlbach, B. K., Salamanca, V. R., Levitt, J. E., Sachs, G. A., Sweeney, M. K., Pohlman, A. S., Charbeneau, J., Krirshman, J. A., & Hall, J. B. (2011). Patient-related factors associated with hospital discharge to a care facility after critical illness. *American Journal of Critical Care*, *20*(5), 378–386. 10.4037/ajcc2011827.

Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of illness in the aged. The index of ADL: A

standardized measure of biological and psychosocial function. *JAMA*, *185*, 914–919. 10.1001/jama.1963.03060120024016.

Kessler, R., Knutson, K. L., Mokhlesi, B., Anderson, S. L., Shah, M., Meltzer, D. O., & Arora, V. M. (2019). Sleep and activity patterns in older patients discharged from the hospital. *Sleep*, *42*(11), zsz153. 10.1093/sleep/zsz153.

Knaus, W. A., Wagner, D. P., Draper, E. A., Zimmerman, J. E., Bergner, M., Bastos, P. G., Sirio, C. A., Murphy, D. J., Lotring, T., & Damiano, A. (1991). The APACHE III prognostic system. Risk prediction of hospital mortality for critically ill hospitalized adults. *Chest*, *100*(6), 1619–1636. 10.1378/chest.100.6.1619.

Lim, S. E. R., Ibrahim, K., Saypr, A. A., & Roberts, H. C. (2018). Assessment of physical activity of hospitalised older adults: A systematic review. *The Journal of Nutrition, Health & Aging*, *22*(3), 377–386. 10.1007/s12603-017-0931-2.

Pavon, J. M., Sloane, R. J., Pieper, C. F., Colón-Emeric, C. S., Cohen, H. J., Gallagher, D., Hall, K. S., Morey, M. C., McCarty, M., & Hastings, S. N. (2020). Accelerometer-measured hospital physical activity and hospital-acquired disability in older adults. *Journal of the American Geriatrics Society*, *68*(2), 261–265. 10.1111/jgs.16231.

Schwab, K. E., To, A. Q., Chang, J., Ronish, B., Needham, D. M., Martin, J. L., & Kamdar, B. B. (2019). Actigraphy to measure physical activity in the intensive care unit: A systematic review. *Journal of Intensive Care Medicine*, *35*(11), 1323–1331. 10.1177/0885066619863654.

Tang, H. J., Tang, H. J., Hu, F. W., & Chen, C. H. (2016). Changes of geriatric syndromes in older adults survived from intensive care unit. *Geriatric Nursing*, *38*(2017), 219–224. 10.1016/j.gerinurse.2016.10.011.

Tasheva, P., Vollenweider, P., Kraege, V., Roulet, G., Lamy, O., Marques-Vidal, P., & Méan, M. (2020). Association between physical activity levels in the hospital setting and hospital-acquired functional decline in elderly patients. *JAMA Network Open*, *3*(1), e1920185. 10.1001/jamanetworkopen.2019.20185.

Wallace, M., & Shelkey, M. (2008). Monitoring functional status in hospitalized older adults. *American Journal of Nursing*, *108*(4), 64–71. 10.1097/01.NAJ.0000314811.46029.3d.