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# Preoperative Nutritional Status and Risk for Subsyndromal Delirium in Older Adults Following Joint Replacement Surgery

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**BACKGROUND:** Subsyndromal delirium following surgery in older adults is related to increased lengths of hospital stay and increased admissions to long-term care. Impaired nutrition increases risk for delirium, but its relationship to subsyndromal delirium remains unclear.
**PURPOSE:** This correlational study examined the relationship between nutritional status and subsyndromal delirium in older adults.
**METHODS:** Assessments for subsyndromal delirium in 53 adults 65 years or older were completed for three consecutive days following joint replacement surgery. Relationships between nutritional status and subsyndromal delirium were analyzed. Level of significance for all tests was set at $p \leq .05$.
**RESULTS:** Participants' scores from the Mini Nutritional Assessment screen were significantly related ($p = .05$) to subsyndromal delirium severity after accounting for variability posed by age and cognition status.
**CONCLUSION:** When preoperative risk assessment of older adults indicates nutritional risk, preoperative optimization may improve effectiveness of delirium prevention efforts.

Subsyndromal delirium (SSD) is common following surgery in adults 65 years or older and is associated with longer lengths of hospital stay, increased admission to long-term care facilities, and a higher risk of death (Cole et al., 2003, 2011; DeCrane et al., 2012). Prevention of delirium symptoms involves reducing the impact of modifiable risk factors prior to surgery. Although evidence exists regarding preoperative nutrition as a risk factor for postoperative delirium (Brooks, 2012; Chung et al., 2015), the relationship between preoperative nutritional status and SSD following surgery remains unclear. Therefore, the purpose of this study was to examine the relationship between the nutritional risk scores of older adult patients scheduled for joint replacement surgery and SSD.

## Background

Delirium is a neurobehavioral syndrome caused by transient disruption of normal neuronal activity as a result of systemic disturbances (Maldonado, 2018), which is usually multifactorial when present in older adults (Inouye et al., 2014). Subsyndromal delirium is present when one or more of the core symptoms of delirium are present without meeting full criteria for delirium (Cole et al., 2013). Subsyndromal delirium may occur in up to 68% of older adults during the early postoperative period (Denny & Lindseth, 2020). Symptoms of SSD usually surface early in the postoperative period, with the highest incidence on the first postoperative day, with gradual decreases in frequency on each of the first three postoperative days following surgery (Shim et al., 2019).

Reduction in SSD is challenging due to a strong association with the nonmodifiable risk factors of advanced age and cognitive impairment (Cole et al., 2012). Thus, the focus of delirium prevention involves reducing the impact of modifiable risk factors, such as functional status (Cole et al., 2012), minimizing preoperative fasting times or dehydration, and encouraging smoking cessation prior to elective surgery (Denny & Lindseth,

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We hereby certify that, to the best of our knowledge, no aspect of our current personal or professional situation might reasonably be expected to affect significantly our views on the subject on which this article discusses.

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2017). Malnutrition is common among older adults, particularly in the context of chronic disease (Lesourd, 2004). Older adults identified preoperatively as "at risk" for decreased nutritional status also have an increased risk for postoperative delirium following orthopaedic surgery (Chu et al., 2015; Mazzola et al., 2017).

In an early study, the body mass index (BMI) of older adults was identified as a risk factor for delirium when the BMI was 22 or less (Culp & Cacchionne, 2008), and in a more recent study when there was low skeletal muscle mass (Mosk et al., 2018). Published guidelines for prevention and management of postoperative delirium recommend optimization of nutrition prior to surgery as a delirium prevention effort (American Geriatrics Society Expert Panel on Postoperative Delirium in Older Adults, 2015).

Both SSD and poor nutritional status were strong predictors with admittance for geriatric institutionalization in one study of 427 patients older than 75 years (Bourdel-Marchasson et al., 2004). In another study of 64 patients diagnosed with SSD and delirium, the 30-day risk of death in these patients was significantly associated with lower levels of albumin ($p = .021$) along with a Cumulative Illness Rating Scale score (Velilla et al., 2013). Yet, in another study where controls were compared with 166 SSD patients, the SSD patients had significantly lower hemoglobin and higher creatinine levels (Zuliani et al., 2013). All three of these studies indicate associations of poor nutritional status and SSD. For example, low albumin levels are associated with improper protein absorption, low hemoglobin levels are associated with poor iron intakes, and increased creatinine levels can be reflective of decreased muscle mass and poor kidney function. Of the few studies we found focusing on SSD and nutritional status of patients, all were more than 5 years old.

As indicated in a review article by Sanford and Flaherty (2014), most studies focusing on the role of nutrition as a cause of delirium (or SSD) tended to focus on describing acute cognitive dysfunction rather than addressing delirium or SSD. Despite the growing body of evidence for nutritional status as a risk factor for delirium, the relationship of baseline nutritional status and postoperative SSD remains unclear. Therefore, given the lack of recent studies on the effects of nutrition on SSD, we have specifically focused our study on the relationship between nutritional status and SSD.

## Operational Definitions

### Subsyndromal Delirium

Subsyndromal delirium was defined as the presence of one or more Confusion Assessment Method (CAM)–Short Form-defined delirium symptoms (acute onset or fluctuating course, inattention, disorganized thinking, or altered level of consciousness; Inouye, 2014), with a Memorial Delirium Assessment Scale ([MDAS]; Breitbart et al., 1997) delirium severity score of 1–13.

### Delirium

Delirium was operationally defined as the presence of one or more CAM-Short Form-defined delirium symptoms (acute onset or fluctuating course, inattention, disorganized thinking, or altered level of consciousness; Inouye, 2014), with an MDAS delirium severity score of greater than 13.

### Nutritional Status

Nutritional status was defined according to the risk categories of the screening portion of the Mini Nutritional Assessment tool (Mini Nutritional Assessment–Short Form [MNA-SF]), which is scored from 0 to 14. Risk categories on the MNA-SF include normal nutritional status (12–14 points) and at risk for malnutrition (≤11 points).

## Methods

### Study Design

This correlational study sought to determine the relationship between preoperative nutritional status and SSD following joint replacement surgery. Inouye and Charpentier's (1996) Multifactorial Model for Delirium was selected to guide this study because of their work indicating that delirium results from a complex interrelationship of baseline predisposing and precipitating factors. This study was part of a larger study that examined the relationship between postoperative pain and delirium severity in older adults (Denny & Such, 2018).

### Sample and Setting

Following approval from the institutional review boards of the principal investigator's (PI's) university and the research site, screening and enrollment were completed at a Midwestern regional medical center in the United States by PI-trained research coordinators at the research site. Eligible study participants were (1) 65 years or older, (2) scheduled for joint replacement surgery with an expected length of stay of at least 24 hours, (3) able to speak and understand English, and (4) were delirium-free at baseline. Our rationale for selecting older adults presenting for joint replacement procedures was that this population typically goes through rigorous preoperative testing to determine whether the benefits of the surgery outweigh the risks. This process presented an opportunity for interventions aimed at nutritional optimization to be initiated preoperatively, potentially reducing risk for SSD. Sixty-two participants were invited to participate in the study after being identified as potentially eligible according to inclusion criteria. Nine refused participation, four withdrew following enrollment, and two cases were excluded because of missing nutritional status data, leaving 47 cases for analysis. Using a power analysis, the final sample size of 47 study participants was determined to be sufficient to detect significant contributing factors for SSD. Statistical power was set a 0.80 with an $\alpha$ of .05 and a conventional effect size of 0.30 ($f^2 = 0.30$) (Cohen et al., 2003) using a post hoc power analysis for four planned predictors with regression equations.

### Tests and Measures

Study measures used to evaluate baseline status at the time of enrollment included the following: (a) the


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MNA-SF; (b) the Mini-Cog (Borson et al., 2000); (c) the CAM–Short Form (Inouye et al., 1990); and (d) the Barthel Index (Mahoney & Barthel, 1965). Each participant was interviewed to complete a brief demographic and medical history questionnaire and baseline assessments.

### Nutritional Status

The MNA tool (Guigoz et al., 1996) was developed by an international research team to assess the risk of malnutrition in the elderly. The screening portion of the MNA tool (MNA-SF), which has specificity of 88.8% and sensitivity of 85.6% in prediction of risk for undernutrition in older adults (Cohendy et al., 2001), was used to identify potential nutritional risk in older adults preparing for orthopaedic surgery. Nutritional assessment data were derived from the patient's electronic health records at the research site to complete the MNA-SF, a six-item screen scored from 0 to 14, with lower scores indicating possible risk for malnutrition and the need for further evaluation using the full MNA. The MNA-SF screens for risk in the following categories: (1) appetite; (2) weight loss; (3) mobility; (4) recent psychological stress; (5) neuropsychological problems (dementia or depression); and (5) BMI. Scores derived from the tool were categorized as normal nutritional status (12–14 points) or at risk for malnutrition (≤11 points) (Cohendy et al., 2001). In addition, we recorded alcohol intake, preoperative fasting time, and BMI. Alcohol intake was assessed through patient interview and recorded as "never," "rare," "occasional," or "daily." Preoperative fasting time (in hours) was obtained from the electronic medical record, which started at the time of last oral intake and ended at the time of surgical incision. Participant preoperative BMI scores for the morning of surgery were obtained from the medical record.

### Cognitive Status

The Mini-Cog cognition assessment was used to provide consistency and structure to the delirium assessments. The Mini-Cog (Borson et al., 2000) dementia screening was completed during the baseline demographic data collection to detect preexisting cognitive impairment prior to the delirium assessments.

### Subsyndromal Delirium Assessments

Delirium assessments of participants were completed using the CAM at baseline by PI-trained research coordinators at the research site and on Postoperative Days 1, 2, and 3 following joint replacement surgery. The CAM, a diagnostic algorithm used to identify core symptoms of delirium, has demonstrated moderate concurrent validity with the Mini-Mental State Examination ($k$ = 0.64) and high interobserver reliability ($k$ = 0.81–1.00) (Inouye et al., 1990). Delirium severity was measured using the MDAS, a clinical-rated tool utilized to evaluate changes in cognitive function, psychomotor activity, and level of consciousness, has an approved interrater reliability (IRR = 0.92), and highly correlates to scores on the Delirium Rating Scale ($r$ = .88, $p \leq$ .0001) (Breitbart et al., 1997). A default MDAS score of "0" was entered when no symptoms were detected on the CAM delirium assessment. The MDAS is scored from 0 to 30, with higher scores denoting increased delirium severity. The MDAS was completed as part of delirium assessments whenever delirium symptoms were detected using the CAM. A cutoff score of 13 was used to indicate full delirium on the MDAS, and SSD severity was defined as a score of 1–13. Prior to completion of CAM delirium assessments, team members were required to complete an instructional module and have IRR established through simultaneous completion of the CAM for participants by the research assistant and the PI.

### Functional Status

The Barthel Index (Mahoney & Barthel, 1965) was used to assess preoperative functional status. The tool is a measure of independence in carrying out activities of daily living. The Barthel Index, which is scored from 0 (complete dependence) to 100 (independent), has a high IRR and internal consistency (ICC = 0.94) and is highly correlated with the Fugl–Meyer Motor Assessment and the Berg Balance Scale.

## Procedures

After obtaining informed consent, preoperative baseline data were collected at the time of enrollment 1–2 weeks prior to the scheduled surgery by one of the PI-trained research coordinators at the study site. If the participant screened negative for delirium, baseline assessments included completion of a questionnaire with demographic and medical history information and cognitive and functional tests. Preoperative nutritional status was recorded onto the MNA nutritional assessment tool using data contained within the electronic health record. Delirium assessments began at least 24 hours after the participant's arrival on the postoperative unit and were completed on Postoperative Days 1, 2, and 3.

## Data Analysis

Pearson $r$ correlations were used to determine relationships between nutritional status variables (individual subscores of MNA, MNA overall score, BMI) and delirium severity as measured by the MDAS delirium severity score. Statistical significance was set at $p \leq .05$. Known risk factor variables correlated with the MDAS overall mean score, with a significance of .10 or less was placed in the first block (age, cognitive status) and nutritional status variables (MNA score, BMI) in the second block of the multiple linear regression model. The MNA score incorporates a measure of BMI; however, all participants in this sample were categorized as "3" according to tool instructions and a correlation between the MNA score and BMI level was nonsignificant. Therefore, BMI levels calculated using the Quetelet Index were analyzed to detect any variability within the sample, Data were analyzed using Statistical Package for the Social Sciences (SPSS) (Version 25).

# Results

## Preoperative Evaluation of Baseline Status

Baseline sample characteristics are reported in Table 1. The nutritional status screening score (MNA-SF) ranged


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**TABLE 1.** Characteristics of Study Sample of Adults Scheduled for Joint Replacement Surgery ($N$ = 47)

| Sample Characteristic | $n$ (%)[a] |
|---|---|
| ***Gender*** *(% women)* | 30 (64) |
| ***Race*** | |
| White | 46 (98) |
| Native American | 1 (2) |
| ***Ethnicity*** | |
| Non-Hispanic | 47 (100) |
| ***Residence*** | |
| Rural | 18 (61.7) |
| Suburban | 29 (38.3) |
| ***Surgical procedure*** | |
| Total knee replacement | 29 (61.7) |
| Total hip replacement | 17 (36.2) |
| Total knee revision | 1 (2.1) |
| ***Primary diagnosis*** | |
| Osteoarthritis | 43 (91.5) |
| Rheumatoid arthritis | 3 (6.4) |
| Other | 1 (2.1) |
| ***Comorbid conditions*** | |
| HTN | 34 (72) |
| CAD | 13 (28) |
| Depression | 12 (26) |
| Diabetes mellitus | 11 (23) |
| Gastroesophageal reflux disease | 10 (21) |
| Sleep apnea | 8 (17) |
| Other cardiac condition, other than CAD or HTN | 8 (17) |
| Hyperthyroidism | 6 (13) |
| Anemia | 6 (13) |
| COPD | 5 (11) |
| Chronic renal disease | 3 (6) |
| Depression | 2 (4) |
| ***Sensory impairment*** | |
| Speech | 3 (6.4) |
| Hearing | 7 (14.9) |
| Vision | 3 (6.4) |
| Vision and hearing loss | 2 (4.3) |
| ***Health-related information*** | |
| Current smoker | 8 (17) |
| Alcohol use | |
| Never | 24 (51.1) |
| Rare | 9 (19.1) |
| Occasional | 12 (25.5) |
| Daily | 2 (4.3) |
| ***Number of prescribed home medications*** | |
| None | 2 (4.3) |
| 1–4 | 15 (31.9) |
| ≥5 | 26 (55.3) |
| Not identified | 4 (8.5) |

*Note*. CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; HTN = hypertension.
[a]Number of participants (percentage of total sample).

from 9.0 to 14.0 ($M$ = 11.96, $SD$ = 1.55). Frequencies for the MNA nutritional status screening components of appetite, weight loss during the last 3 months, mobility, psychological stress or acute illness during the last 3 months, neuropsychological diagnoses of dementia or depression, and BMI categories are reported in Table 2. Other nutrition-related characteristics of participants included preoperative BMI levels ($M$ = 31.30, $SD$ = 5.46, range = 21.6–45.1) and the preoperative fasting time ($M$ = 13.67, $SD$ = 3.56, range = 4–20 hours). Cognition of participants, assessed using the Mini-Cog, ranged from 2 (cognitive impairment present) to a maximum score of 5 (no cognitive impairment) ($M$ = 4.49, $SD$ = 0.86). The Barthel Index functional status score (0–100) ranged from a minimum score of 80 to 100 ($M$ = 97.45, $SD$ = 4.5).

## Subsyndromal Delirium and Delirium Severity

The CAM scores indicated that SSD was present in 34 (72%) of 47 participants on at least one of the three postoperative days following joint replacement surgery, whereas one (2%) of the 47 participants went on to develop delirium, with an MDAS severity score of 15 out of 30 on one of the three postoperative days. No delirium symptoms were detected in 12 (26%) of the participants. Subsyndromal delirium (SSD) with one core delirium symptom was identified in 20 (43%) of the participants, whereas SSD with two core delirium symptoms was identified in 14 participants (30%; $n$ = 14) during the 3-day postoperative period. The overall mean MDAS delirium assessment severity score for the 3-day postoperative study period was 1.85 and ranged from 0 (least severe) to 9.7 (most severe). The mean MDAS delirium scores ranged from 0 to 15 for the first two postoperative days, with the mean MDAS score for the first day being 2.3 and for the second day being 2.0. The MDAS score for the third postoperative day ranged from 0 to 13, with a mean of 2.2. Of 34 participants, the severity of delirium symptoms detected in this sample using the MDAS was dominated by SSD ($n$ = 34) whereas delirium severity in one participant was mild (MDAS score of 15 on Postoperative Day 2).

## Nutritional Status and Subsyndromal Delirium

The preoperative MNA screening score was not significantly related to the mean MDAS delirium scores for the 3-day study period (see Table 3). However, the preoperative MNA nutritional assessment scores were significantly related ($r$ = .29, $p$ = .05) to an overall mean MDAS delirium severity score of 2 or greater. Lower BMI levels were also significantly related ($r$ = .32, $p$ = .02) to an MDAS delirium severity score of 4 or greater on Day 1, which is consistent with subsyndromal level of delirium severity.

## Preoperative Risk Factors and Subsyndromal Delirium

The demographic variables of age and Mini-Cog cognition scores were correlated with mean MDAS delirium severity scores for the 3-day study period (age: $r$ = .45, $p$ = .002; cognitive status: $r$ = −.26, $p$ = .07) (see Table 4). Age was significantly related to increased delirium

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**TABLE 2. MINI NUTRITIONAL ASSESSMENT SCREENING SCORES OF POTENTIAL NUTRITIONAL RISK IN ADULTS SCHEDULED FOR JOINT REPLACEMENT SURGERY ($N$ = 47)**

| | Frequency of Responses | Mean | *SD* | Range |
|---|---|---|---|---|
| ***Components of MNA-SF screening tool*** | | | | |
| **Appetite** | | 1.92 | 0.28 | 1.0–2.0 |
| 0 = Severe decrease | 0 | | | |
| 1 = Moderate decrease | 4 | | | |
| 2 = No decrease | 43 | | | |
| **Weight loss** | | 2.53 | 0.75 | 0–3.0 |
| 0 = >3 kg | 2 | | | |
| 1 = Does not know | 1 | | | |
| 2 = Between 1 and 3 kg (2.2–6.6 lb) | 14 | | | |
| 3 = No weight loss | 30 | | | |
| **Mobility** | | 1.62 | 0.49 | 1.0–2.0 |
| 0 = Bed- or chairbound | 0 | | | |
| 1 = Able to get up, but not go out | 18 | | | |
| 2 = Goes out | 29 | | | |
| **Psychological stress or acute illness** | | 1.68 | 0.73 | 0–2.0 |
| 0 = Yes | 7 | | | |
| 2 = No | 40 | | | |
| **Neuropsychological problems** | | 1.28 | 0.90 | 0–2.0 |
| 0 = Severe dementia or depression | 14 | | | |
| 1 = Mild dementia | 6 | | | |
| 2 = No psychological problems | 27 | | | |
| **BMI categories** | | 3.00 | 0 | N/A |
| 0 = <19 | 0 | | | |
| 1 = 19–20 | 0 | | | |
| 2 = 21–22 | 0 | | | |
| 3 = ≥23 | 0 | | | |
| **MNA-SF total score** | 47 | 11.96 | 1.55 | 9.0–14.0 |

*Note*. BMI = body mass index; MNA-SF = Mini Nutritional Assessment–Short Form. Used with permission from Oxford University Press, 2020.

severity on each of the three study days, and the Mini-Cog score was inversely related to an overall mean MDAS score of 2 or greater ($r$ = −.36, $p$ = .01). The MNA-SF screening score was not related to either age ($r$ = −.23, $p$ = .11) or cognition scores ($r$ = .11, $p$ = .44); however, MNA scores of 10 or less were significantly related to age ($r$ = .31, $p$ = .03). The Barthel Index functional status score and preoperative fasting time were not correlated with SSD (Barthel score: $r$ = −.20, $p$ = .19; fasting time: $r$ = .09, $p$ = .54), nor were self-reported alcohol intakes or the American Society of Anesthesiologists score. When MNA nutrition scores were included in a linear regression model along with age, cognition, and BMI, the model accounted for 26% of the variance for development of subsyndromal delirium severity (see Table 5).

## Discussion

Our study examined the relationship between nutritional status and SSD in older adults following orthopaedic surgery in which 72% of participants developed delirium symptoms of SSD severity (34 of 47 total participants). Subsyndromal delirium was detected in 20 participants (42%) on Postoperative Day 1, in 20 participants (42%) on Postoperative Day 2, and in 23 participants (49%) on Day 3. Lower preoperative MNA nutrition status scores were significantly related to having an SSD severity score of 2 or more on the MDAS delirium severity scale. When MNA nutrition status scores, BMI levels, participants' ages, and postoperative cognition scores were entered into a hierarchical linear regression, these factors accounted for 26% of the variance in developing SSD. Although age and cognitive impairment are the most prominent risk factors for SSD (Cole et al., 2013; Denny & Lindseth, 2017), our study indicated nutritional status was an important risk factor for developing SSD symptoms.

The common finding of SSD in our study shows the importance of systematic preoperative risk assessment to identify potentially modifiable risk factors, such as nutritional status. The MNA nutritional status scores in this study were significantly related ($r$ = .29, $p$ = .05) to SSD severity on the MDAS delirium scale in our study of older adults who had joint replacement surgery. Investigators of a previous study using the MNA screening tool recommended MNA scores of 11 or less to be considered as an independent risk factor for delirium in older adults following hip fracture surgery (Mazzola et al., 2017). The researchers recommended preoperative screening using the MNA-SF in such patients to predict risk for postoperative delirium. Of interest, this


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**TABLE 3. RELATIONSHIPS AMONG NUTRITION-RELATED VARIABLES AND SUBSYNDROMAL DELIRIUM[a] (N = 47)**

| | Postoperative Day 1 | | Postoperative Day 2 | | Postoperative Day 3 | | Postoperative Days 1-3 | |
|---|---|---|---|---|---|---|---|---|
| Variable | *r* | *p* | *r* | *p* | *r* | *p* | *r* | *p* |
| MNA total score | −.06 | .69 | −.08 | .55 | −.10 | .49 | −.09 | .51 |
| MNA score ≤10 | .17 | .27 | .27 | .06 | .15 | .30 | .24 | .10 |
| BMI[b] | −.31* | .03 | −.15 | .30 | −.05 | .72 | −.21 | .13 |
| Preoperative fast time (in hours) | .15 | .29 | .02 | .89 | .04 | .78 | .09 | .53 |
| Alcohol intake[c] (scored from 0 to 3) | −.03 | .84 | −.08 | .58 | .11 | .44 | −.01 | .97 |

*Note*. BMI = body mass index; MNA = Mini Nutritional Assessment.
[a]Subsyndromal delirium was operationally defined as a score of 1–13 on the Memorial Delirium Assessment Scale, which is scored from 0 to 30.
[b]Actual BMI values were calculated for this table.
[c]Alcohol intake was self-reported and scored from 0 to 3 (0 = never, 1 = rare, 2 = occasional, or 3 = daily).
$*p \leq .05$.

study found that an MNA score of 10 or less ($r = .39$, $p = .007$) increased the risk for SSD after joint replacement.

The clinical importance of identifying SSD in older adults following surgery has been identified previously (Cole et al., 2011; DeCrane et al., 2012; Shim et al., 2019). Although recovery from SSD is typically shorter than for delirium, Cole et al. (2016) reported partial or no recovery from SSD in older adults at 1 month following hospital discharge in a mixed sample of older adults admitted for surgical or medical indications. Rather than a short transient course, SSD may persist and contribute to negative outcomes several months after surgery. Like delirium, SSD may increase the risk for transfer to a care facility following hospital discharge (Bourdel-Marchasson et al., 2004) and mortality at 1 year postdischarge (Aliberti et al., 2015). Because nutritional status represents a modifiable preoperative risk factor, older adults identified as "at risk" on the MNA tool could be referred for nutritional status optimization prior to the scheduled surgery.

Cognitive impairment is a known risk factor for SSD. Therefore, cognition was evaluated at the time of enrollment in the current study. Dworkin et al. (2016) suggested the Mini-Cog be used by physicians before offering surgery to determine whether or not to offer surgery as an option to patients. The researchers reported that older adults with preoperative Mini-Cog scores of 3 or less in participants without previously diagnosed dementia had increased delirium risk. This is consistent with our finding that a preoperative Mini-Cog score of 3 or less was significantly related to SSD with an MDAS score of 2 or more ($r = -.34$, $p = .02$) in older adults following joint replacement surgery. Age has been documented consistently as a risk factor for delirium—especially in older adults who undergo total knee arthoplasty (Chung et al., 2015). Findings from previous studies (van Meenen et al., 2014) concur with our study findings, identifying cognitive impairment and advanced age as significantly related to increased delirium severity. In the current study, we found that MNA scores of 10 or less were significantly related to increased age ($r = .31$, $p = .03$), showing the importance of nutritional interventions for older patients.

## LIMITATIONS

We note some limitations of our study. For example, because of the observational study design, causal inferences cannot be inferred from study findings. Also, our

**TABLE 4. RELATIONSHIPS AMONG PREOPERATIVE RISK FACTORS AND SUBSYNDROMAL DELIRIUM[a] (N = 47)**

| | Postoperative Day 1 | | Postoperative Day 2 | | Postoperative Day 3 | | Overall | |
|---|---|---|---|---|---|---|---|---|
| Risk Factor | *r* | *p* | *r* | *p* | *r* | *p* | *r* | *p* |
| Age (in years) | .53** | <.001 | .28* | .05 | .29* | .04 | .45** | .002 |
| Cognition status[b] (Mini-Cog score) | −.07 | .63 | −29* | .04 | −31* | .03 | .26 | .07 |
| Functional score (Barthel Index 0–100) | −.39** | .007 | −.02 | .90 | −.05 | .72 | −.20 | .18 |
| ASA[c] score | .10 | .52 | .10 | .52 | .18 | .23 | .14 | .33 |

*Note*. ASA = American Society of Anesthesiologists.
[a]Subsyndromal delirium was operationally defined as a score of 1–13 on the Memorial Delirium Assessment Scale.
[b]Cognitive status was scored using the Revised Mini-Cog (scored from 0 to 5), with lower scores indicating lower cognition.
[c]The ASA score was developed to assess patient physical status prior to surgery and includes six categories scored from 1 to 6.
$*p \leq .05$, $**p \leq .01$.


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**Table 5. Hierarchical Multiple Linear Regression Analyses for Relationship Between Nutritional Status and Subsyndromal Delirium[a] in Older Adults following Joint Replacement Surgery ($N$ = 47)**

| Predictor Variables | Part Correlation ($sr^2$) | Cumulative $R^2$ | $b$ | $\beta$ |
|---|---|---|---|---|
| **Block 1** | | | | |
| Age | .43* | .20 | .16* | .43 |
| Cognition score | −.22 | .25 | .72 | −.22 |
| **Block 2** | | | | |
| MNA score ≤10 | .09 | .26 | .81 | .10 |
| BMI | −.05 | .26 | −.03 | −.05 |
| $R^2$ = .26*, $F$(4, 42) = 3.75*, $p$ = .01; adjusted $R^2$ = .19 | | | | |

*Note.* BMI = body mass index; MNA = Mini Nutritional Assessment.
[a]Mean delirium severity scores were calculated using Memorial Delirium Assessment Scale scores from Postoperative Days 1, 2, and 3.
*$p \leq .05$.

study sample was primarily homogeneous and lacked racial or ethnic diversity, which may limit application to other populations. Because of use of participants' medical records for nutritional information, we may have underestimated the impact of nutritional status on SSD severity. For example, the MNA-SF is intended to be used as a screen for potential malnutrition risk, with further assessment using the full MNA tool if risk is identified. The sample size of the current study was relatively small, although adequate statistical power was confirmed through post hoc analysis. Furthermore, our findings should be evaluated cautiously as linear regressions used for data analysis are generally reserved for larger sample sizes. Furthermore, although we found age, cognition, and MNA nutrition score to contribute to 26% of the variance in SSD symptoms among participants, this study did not identify other significant delirium risk factors that likely play a role in SSD, making up the other 74% of the variance.

## Implications for Orthopaedic Nursing Practice

Inclusion of routine preoperative nutritional risk evaluation may strengthen delirium prevention strategies for older adults. Detection of impaired nutritional status presents an opportunity to improve delirium outcomes through proactive preoperative interventions. Elective joint replacement procedures are most often nonemergent and could be delayed to allow for time to boost nutritional status prior to surgery. Guidelines published by the American Geriatrics Society Expert Panel on Postoperative Delirium in Older Adults (2015) recommends having an interdisciplinary focus to preoperative care that includes pharmacological and nonpharmacological measures (reorientation, medication management, early mobility, nutrition, and gastrointestinal motility) for minimization of the delirium risk associated with orthopaedic surgeries. Our findings point to a relationship between preoperative nutritional status in older adults who often present for joint replacement surgery with the presence of chronic disease and reduced immune response related to advanced age (Lesourd, 2004) and SSD. Preoperative testing procedures could be adapted to incorporate a "pause" in recommending surgery while nutritional interventions are implemented when nutritional assessment scores indicate nutritional risk. Assessing nutritional status in preparation for joint replacement surgery may improve outcomes in social, mental, cardiovascular, and metabolic health that extends beyond the recovery period following surgery.

## Conclusions

This study examined the relationship between nutritional status and SSD. Although known predictors of SSD are often nonmodifiable (age and cognitive status), nutritional status is a risk factor amenable to preoperative optimization. Assessing nutritional status in preparation for joint replacement surgery may reduce delirium as well as improve other outcomes. Improved nutrition contributes to the holistic health of older adults that continues beyond the postoperative recovery period.

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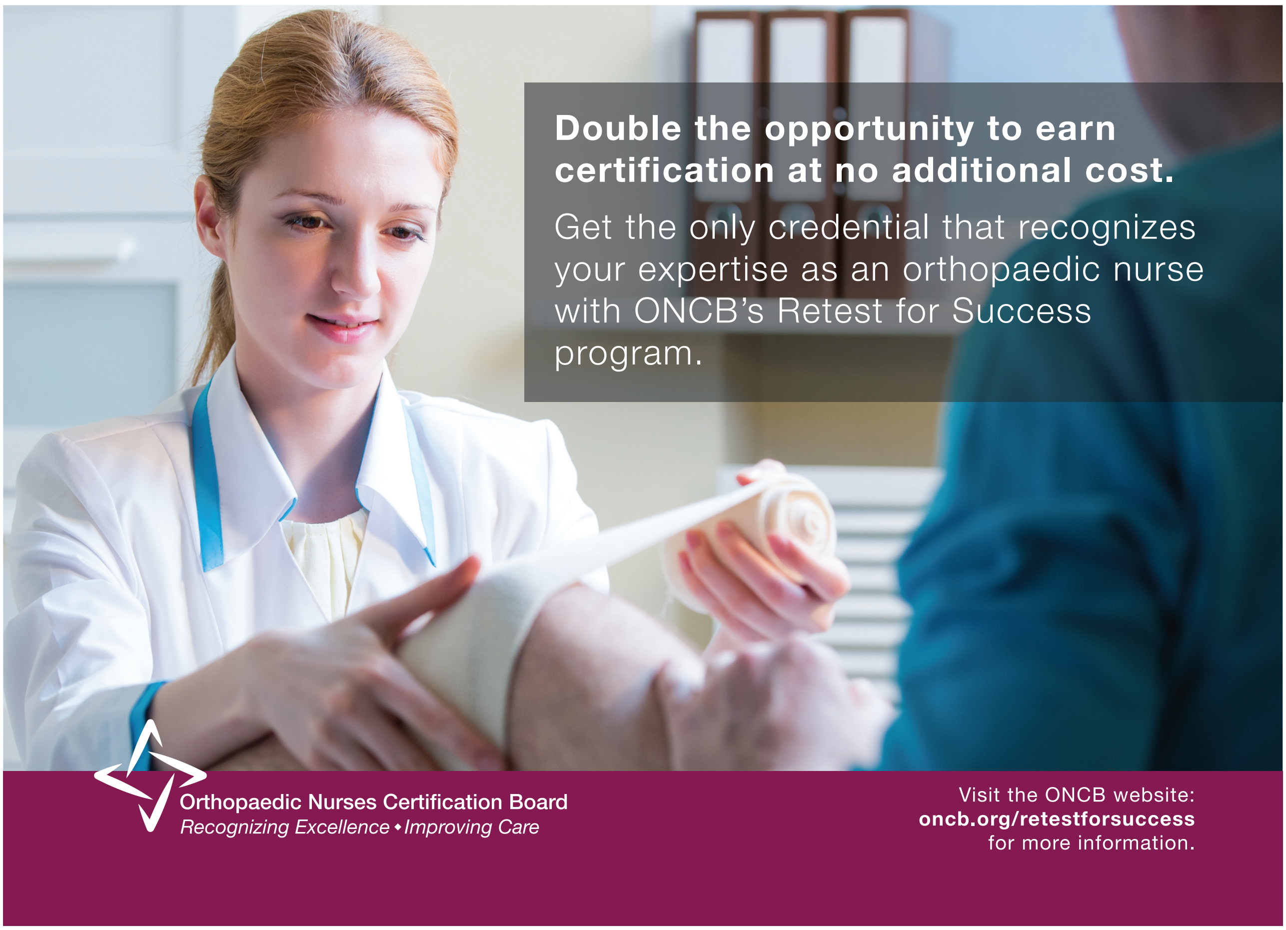


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