



Article

Short Sleep Duration Is Associated with More Intense Musculoskeletal Symptoms in Day-Shift Nurses: An Observational Study

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Abstract

Musculoskeletal symptoms (MSS) and sleep problems are prevalent in nurses. Evidence exploring associations between sleep and MSS in nurses is limited by self-reported sleep measures and recalling MSS over a long period. The purpose of this study was to examine the relationship between MSS and sleep in nurses using objective sleep measures and real-time MSS assessment. This 7-day observational study included 31 nurses who work day shifts. Sleep duration and efficiency were measured using accelerometers, and MSS were reported using ecological momentary assessment. Sleep metrics and MSS were compared between workdays and days off, and a regression model analyzed the effect of sleep duration on MSS while controlling for age and body mass index (BMI). On average, nurses did not sleep the minimum recommended duration of 7 h (6.28, SD = 1.31), and they slept significantly less prior to a workday (5.98 h, SD = 1.12) than a day off work (6.69 h, SD = 1.43) ($t(185) = -5.92, p < 0.0001$). Short sleep duration was associated with 18% higher MSS when controlling for age and BMI ($t(822) = 2.63, p = 0.009$). Understanding the association between sleep and MSS is important to healthcare organizations and policy makers because sleep is essential for health and recovery, and occupational characteristics, such as shift length and consecutive shifts, influence sleep. Nurse fatigue is detrimental to patient safety and the health of the nursing workforce, and musculoskeletal problems contribute to nurse attrition. This study may inform future research on organizational policies related to nurse fatigue and musculoskeletal symptoms.

Keywords: musculoskeletal pain; occupational health; sleep; nurses; fatigue



Academic Editor: Shuchang He

Received: 14 January 2026

Revised: 13 February 2026

Accepted: 28 February 2026

Published: 2 March 2026

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1. Introduction

Prevalence of musculoskeletal and sleep disorders are higher in nurses than other healthcare professions [1], emphasizing the need to better understand the relationship between these two health factors in the nursing workforce. The relationship between high rates of musculoskeletal symptoms (MSS) and physical strain during patient handling is well-established in the literature [2–5]. Previous research largely focused on safe patient handling and lifting equipment to improve physical safety and reduce work-related injuries

in nurses [5–9]; however, MSS prevalence among nurses remains as high as 77% worldwide [10]. Additional research is needed to understand the relationship between MSS and health behaviors in nurses as an approach to Total Worker Health® [11].

Total Worker Health® [11] is an occupational health approach that expands beyond the physical risks in the workplace by also considering workplace psychological factors and the health of the individual worker. Workplace psychological factors include workplace policies and culture, evaluation methods, and compensation. Individual health factors, including diet, exercise, and sleep, all contribute to MSS and the overall health of the worker. This study specifically adds to the body of knowledge on the relationship between MSS in nurses and their sleep.

Sleep is essential for function and recovery, and poor sleep increases morbidity and mortality in the general population [12–17]. Nurses, on average, do not meet the recommended minimum of 7 h of sleep, which affects the health of the workforce, patient safety, and quality of patient care [18–21]. Sleep duration and MSS influence nurse attrition, which is detrimental to patient outcomes and costly to healthcare organizations [22–25].

The relationship between MSS and sleep in nurses was explored using self-reported measures with mixed findings. Insufficient sleep duration and quality were associated with discomfort and functional limitations in multiple studies [26–28]; however, alternative findings showed MSS were associated with physical workload and only weakly associated with sleep [1]. Additional research using objective measures of sleep and reduced recall bias of MSS symptoms is needed to clarify the relationship between MSS and sleep.

Sleep is an individual health behavior; however, occupational characteristics influence sleep quality and quantity [29]. High job demand, low job control, and lack of support influence sleep and wake times [29], and long work hours decrease time for recovery from work [21,30]. Professional and regulatory organizations, such as the American Academy of Nursing, The Joint Commission, the National Institute of Occupational Safety and Health, and the Occupational Safety and Health Administration, acknowledge the relationship between occupational characteristics and sleep in nurses [31–34]. These organizations recommend implementation of a Fatigue Risk Management Plan, such as those used in the aerospace and aviation industries [31–34]. There is not currently a mandated Fatigue Risk Management Plan for the United States nursing profession, and more objective measures of sleep and its effect on nurse well-being can inform development of such public policy in the future.

The purpose of this study was to examine the relationship between MSS and sleep in nurses who work day shifts. We hypothesized that objectively measured short sleep duration and low sleep efficiency would be associated with higher musculoskeletal symptom intensity in day-shift nurses, controlling for individual characteristics such as age and body mass index. This study builds on prior research by using objective measurements of sleep quality and duration and real-time assessment of MSS, which can inform occupational health policy development for organizations that employ nurses as well as associations and policy makers that advocate for the nursing profession and patient safety.

2. Materials and Methods

2.1. Research Design

Ecological momentary assessment of MSS and direct measurement of sleep using a wrist-worn accelerometer were used in this cross-sectional, observational study with a duration of 7 consecutive days.

2.2. Participants

Sample size was calculated using the UCSF Clinical & Translational Science Institute Sample Size Calculators [35], and 29 participants were needed for a desired power of 0.80 and a Type I error rate of 0.05. A convenience sample of nurses in Texas was recruited at the end of an online survey used in a previous study [36]. The survey asked each nurse if they would like to participate in additional research involving sleep and musculoskeletal symptoms, and nurses who indicated they would like to participate were screened for eligibility. The pool of potential participants included 173 nurses who spend at least 50% of their work hours in direct patient care roles, was predominantly female (96%), white (61% non-Hispanic; 29% Hispanic), and had a mean age of 41.45 years [36]. The methods used for direct measurement of sleep required an investigator to meet with nurses in person; therefore, only nurses in the Houston and Central Texas areas were included. Due to feasibility constraints, the convenience sample used in this study may not fully represent the nursing workforce as a whole.

Participants provided informed consent electronically during an in-person meeting with the primary investigator, and they were compensated with a retail gift card. Ethics approval was obtained from the Institutional Review Board at University of the Incarnate Word (2023-1397-EXP).

Nurses, aged 18 to 65, who worked day shifts in a direct patient care role were eligible for inclusion. Because postoperative symptoms may influence perception of MSS, nurses were excluded if they had surgery in the past 3 months. Working night shifts influences sleep quality and duration; therefore, night shift work was also an exclusion criterion. A homogeneous sample of nurses who work day shift controlled for confounding sleep variations associated with working night shifts.

2.3. Measures

2.3.1. Musculoskeletal Symptoms

Participants reported intensity of musculoskeletal symptoms 4 times per day using ecological momentary assessment. Nurses received text messages at 6:00 a.m., 12:00 p.m., 6:00 p.m., and 9:00 p.m. containing a link to a brief Qualtrics survey (Qualtrics, Provo, UT, USA) where nurses rated MSS intensity from 0 to 10 (0 = no symptoms, 10 = most severe). Nurses were asked to indicate the location of their symptoms according to the body regions of the Nordic Musculoskeletal Questionnaire: neck, shoulders, upper back, elbows, low back, wrist/hands, hips/thighs, knees, or ankles/feet [37].

Participants were asked to rate their severity of musculoskeletal symptoms rather than their pain so that perceptions of discomfort, stiffness, and pain were included. Musculoskeletal symptoms were operationally defined as any of the following sensations: pain, stiffness, soreness, or aches. Clinically, patients may not interpret discomfort or stiffness as pain. Patients interpret pain as more intense and harmful compared to discomfort and stiffness [38]. Discomfort was used to describe symptoms that 'can be ignored' or are 'not harmful' [38]. Stiffness was described as limited movement or mobility [38]. The term symptoms has been used with a 0 to 10 numeric rating scale in studies of allergic rhinitis, asthma, anxiety, and gastrointestinal problems with acceptable psychometric properties [39–43].

2.3.2. Sleep

Sleep was measured using an accelerometer (ActiGraph GT9X link, ActiGraph, Pensacola, FL, USA) worn on the non-dominant wrist 24 h per day for 7 consecutive nights and days. The devices began sampling at 8 p.m. on night 1 using a sampling rate of 30 Hz. Nurses continued their activities as usual and were instructed to notify the primary investigator if they removed the device. Accelerometry data was stored on the ActiGraph,

which was retrieved by the primary investigator at the end of the data collection period. The data was then manually uploaded to ActiLife software version 6.13.4 (ActiGraph, LLC., Pensacola, FL, USA) where it was converted into sleep metrics using the Cole-Kripke algorithm [44].

Because actigraphy is less consistent in estimating sleep onset than polysomnography, nurses answered sleep diary questions [45,46]. The 6:00 a.m. Qualtrics survey included prompts to report time to bed, time out of bed, and any unusual activity the previous night [46]. In and out of bed times were manually adjusted within the ActiLife sleep dashboard, if necessary.

Sleep metrics included sleep duration and sleep efficiency. Sleep duration is the amount of time asleep, and 7 h was used as the cutoff for sufficient sleep duration because it is the minimum recommended sleep duration for the general population [18]. Sleep efficiency is the proportion of time asleep to time in bed, and it is reported as a percentage. Higher sleep efficiency is associated with better health benefits, and the threshold for normal sleep efficiency is 80% to 85% [47,48].

2.3.3. Data Analysis

After sleep data was exported from ActiLife software, a new dichotomous variable for sleep duration category was created: <7 h or ≥ 7 h. Because of the systemic effects of sleep on overall musculoskeletal health, general musculoskeletal symptom ratings were used for data analysis rather than ratings for specific body regions. Additionally, the location of symptoms is of less clinical relevance to this study than overall perception of musculoskeletal health. Non-specific MSS ratings were aligned with sleep data from the previous night, and missing MSS ratings were calculated using an average of the ratings for that day. If sleep data was not captured (e.g., the nurse removed the ActiGraph), associated MSS ratings for that night were not included.

Descriptive statistics were calculated for participant characteristics, MSS ratings, and sleep metrics. Visual inspection of MSS ratings showed an abnormal distribution, with a high number of 0 ratings and positive skewness. A negative binomial distribution was used to control for overdispersion in MSS outcomes because the variance ($\sigma^2 = 4.01$) was greater than the mean ($\mu = 2.26$). Univariate analyses were then calculated for differences in MSS by workday and day off using a generalized linear mixed model with a log link and random effect for repeated measures by subject.

Sleep metrics were also compared by workday and day off. Sleep metrics followed a normal distribution; hence, it was used for all comparisons of sleep outcomes, except for the sleep duration category. Sleep duration category was coded as a dichotomous variable (<7 h or ≥ 7 h), so a binomial distribution was used to analyze outcomes by sleep duration category. The same univariate procedure for analyzing MSS was used to examine sleep duration category with shift length, work setting, and ethnicity.

Finally, a regression model analyzed MSS as a function of sleep duration category while controlling for age and BMI. A generalized linear mixed model with a log link and random effect for repeated measures by subject was also used for the regression analysis.

Non-random sampling was used due to feasibility constraints; however, implementation of inferential statistics to test within-subject differences across repeated measures is supported by the Central Limit Theorem with a sample size of $N = 31$ and a high number of repeated musculoskeletal symptom measures [49]. Additionally, use of a Generalized Linear Mixed Model with a log link and random effect provided an appropriate framework for modeling count data with overdispersion [50,51].

To present statistical significance, we reported t -statistics, defined as regression parameter estimates scaled by their standard errors, along with the corresponding p -values.

3. Results

3.1. Participant Characteristics

Participant characteristics are presented in Table 1. Of the 173 nurses who were invited to participate, 31 nurses enrolled in the study. Thirty participants were women (97%). The average participant age was 40.58 years (SD = 0.92), and average BMI was 29.09 (SD = 5.79). Most participants identified as white, non-Hispanic (52%) or white, Hispanic (42%).

Table 1. Sociodemographic and work-related variables.

Characteristics		N = 31	Percent
Gender	Male	1	3.2
	Female	30	96.8
Race/Ethnicity	Black/African American	1	3.2
	White, non-Hispanic	16	51.6
	White, Hispanic	13	41.9
	Other race/ethnicity	1	3.2
Work Setting	Hospital	22	71
	Outpatient, urgent care, surgery center	3	9.7
	Home health	4	12.9
	Other ^a	2	6.5
Days of Participation	5 days	1	3.2
	6 days	1	3.2
	7 days	29	93.6
Workdays	2–3 days	14	45.2
	4–5 days	15	48.4
	6–7 days	2	6.4

^a School nurse and transport nurse.

Twenty-nine nurses participated all 7 days, one nurse participated 6 days, and one nurse participated 5 days, for a total of 214 nurse-days. Nine of the 31 participants missed at least one MSS reporting period, resulting in 13 missing data points. After adjusting for incomplete data, a total of 855 MSS ratings were included in the sample.

Out of 214 nurse-days, 119 (56%) were workdays and 95 (44%) were days off. Most participants (72%) worked in a hospital setting, while the remaining nurses worked in an outpatient, urgent care, home health, school, or transport nurse role. Average shift length was 10.73 h (SD = 2.67).

3.2. Musculoskeletal Symptoms

The average MSS rating was 2.26 (SD = 2.00), and scores ranged from 0 to 9. Symptom ratings on workdays (M = 2.14, SD = 1.99) were significantly higher than on days off (M = 2.05, SD = 1.68) ($t(823) = 4.76, p < 0.0001$). Nurse reported MSS in the low back region most frequently.

3.3. Sleep

Nurses slept an average of 6.28 h per night (SD = 1.31, min = 1.92, max = 10.22). Before a workday, nurses slept 5.98 h (SD = 1.12), on average, which was significantly less than the duration of 6.69 h (SD = 1.43) prior to a day off ($t(185) = -5.92, p < 0.0001$) (Figure 1). Overall average sleep efficiency was 82% (SD = 8.14), ranging from 47.92% to 97.50%. Average sleep efficiency prior to a workday was 83.12% (SD = 8.77) and 80.95% prior to a day off (SD = 7.65). Nurses slept less than 7 h a night on 70.51% of the nights included in the study (n = 153) and 7 h or more 29.49% of the time (n = 64).

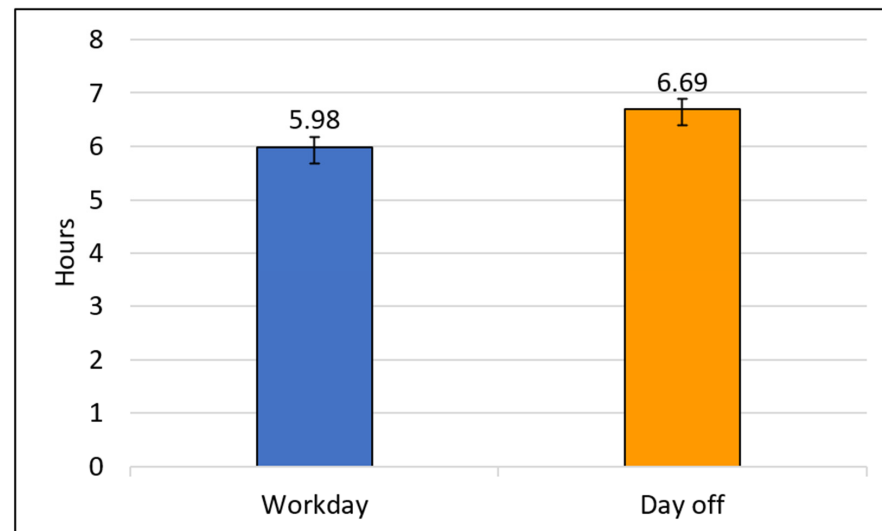


Figure 1. Average sleep duration before a workday and a day off. Nurses slept significantly less before a workday than before a day off, with an estimated difference of 0.71 h (95% CI [0.63, 1.15], $p < 0.0001$).

3.4. Univariate Associations

Nurses had 18% higher expected MSS ratings, on average, when they slept less than 7 h per night, compared to sleeping 7 h or more ($t(823) = 2.56$, $p = 0.01$). Sleep efficiency was not significantly associated with MSS ratings, and none of the sleep metrics were significantly associated with work setting, shift length, ethnicity, age, or BMI. However, older age and higher BMI were both significantly associated with higher MSS ratings in univariate analyses ($t(823) = 2.29$, $p = 0.02$; $t(824) = 3.23$, $p = 0.001$).

Significant differences in sleep metrics were found when comparing by workday and day off. When sleep was evaluated before a workday and a day off, sleep duration was significantly shorter the night prior to a workday ($t(185) = -5.92$, $p < 0.0001$) compared to a day off. The odds of sleeping less than 7 h, defined as the probability of sleeping less than 7 h divided by one minus that probability, were 5.93 times higher the night before a workday than before a day off ($t(185) = 4.55$, $p < 0.0001$). Sleep efficiency was not significantly different prior to workdays and days off.

3.5. Multivariable Model

A regression analysis modeled MSS rating as a function of sleep duration category (<7 h or ≥ 7 h) while controlling for age and BMI. Sleeping less than 7 h was significantly associated with higher MSS ratings ($t(822) = 2.63$, $p = 0.009$) when controlling for age and BMI. Expected MSS ratings are 18% higher, on average, when nurses slept less than 7 h per night compared to sleeping 7 h or more, when controlling for age and BMI. Age approached a significant association in this model, with higher age associated with higher MSS ratings ($t(822) = 0.0223$, $p = 0.07$). Body mass index was significantly associated with higher MSS ratings ($t(822) = 0.0584$, $p = 0.005$). Results of the regression analysis are shown in Table 2.

Table 2. Regression model explaining associations between musculoskeletal symptoms, sleep duration, age, and body mass index.

Variable	Estimate	Standard Error	DF	t Value	p
<7 h of sleep	0.17	0.0693	822.00	2.63	0.009 *
≥ 7 h of sleep	0.00				
Age	0.02	0.0121	822.00	1.84	0.07
Body Mass Index (BMI)	0.06	0.0205	822.00	2.85	0.005 *

* $p < 0.01$.

4. Discussion

4.1. Discussion of Study Results

On average, nurses in this study slept less than the recommended 7 h per night, and they slept even less prior to a workday compared to a day off, which is consistent with previous research [19]. Although the mean difference in MSS ratings between a workday and a day off was statistically significant, the absolute difference falls short of a minimally clinically important difference (MCID). The MCID of a numeric pain rating ranges from 1.0 to 2.0 [52–54], and the absolute difference between workday and day off symptom ratings in this study is 0.09.

Shorter sleep duration was associated with higher non-specific MSS ratings the following day. When controlling for age and BMI, sleeping less than 7 h was associated with 18% higher expected non-specific MSS symptoms compared to sleeping 7 h or more. The observed association between sleep duration and non-specific MSS ratings is clinically meaningful in the context of occupational health. On a 0–10 symptom scale, this magnitude of difference may translate to a clinically important change, depending on baseline symptom levels. When baseline symptoms are above 5 out of 10, an 18% change is within the range of an MCID [52–54].

Sleep efficiency was not associated with MSS, which may be due to average sleep efficiency being within normal range [47,48]. Since nurses in this study experienced consistently short sleep duration, they may have experienced strong drive for deep sleep, which reduces variability in sleep efficiency [55].

Age and BMI were associated with significantly higher non-specific MSS ratings, which is consistent with previous research [56–59]. Contrary to the published literature [14,60–62], age and BMI were not associated with sleep quantity or quality. This may be due to the average sleep duration in this study (6.28 h) being shorter than the average sleep duration in the general adult population (6.5 to 7 h) [62]. Sleep duration was shorter prior to a workday than a day off, which may be related to early shift start times and long shift lengths, combined with the need for recovery after a workday [19]. Sleep duration prior to a day off was only 6.69 h, which is still short of the recommended 7-h minimum for health benefits [18]. Nurses may need even longer than 7 h for adequate recovery from the physical and psychological demands of their job [63–65].

The findings in this study have potential clinical implications related to the health of the nursing workforce and the quality and safety of patient care. Musculoskeletal problems are one of the reasons nurses leave their job or leave the profession altogether [22,23,66]. Attrition causes staffing shortages which negatively impact patient care, leaves remaining nurses with higher job demands, and costs healthcare organizations millions of dollars [25]. Individual fatigue results in impaired job performance and less ability to cope with stress [19,67]. Sleep is an individual health behavior; however, organizational factors, such as long work hours and consecutive shifts, may create barriers to achieving sufficient sleep duration. Occupational interventions that address sleep may include self-scheduling, shorter shift length, more recovery time between shifts, and using wearable activity monitors to assess sleep-wake patterns that can inform individual sleep behavior change [68].

4.2. Study Limitations

These findings should be interpreted with caution because causality cannot be determined between MSS and sleep, MSS and work, or work and sleep due to the observational, cross-sectional study design using a relatively small sample of nurses. Moreover, the inferential results are limited to a selected sample of nurses. Although the sample size meets the criteria for adequate statistical power, a larger sample of nurses selected through

systematic random sampling across different geographical regions may reveal different trends in work, sleep, and MSS and enhance the generalizability of the findings.

The study is further limited by a 7-day data collection period which may not be reflective of long-term or habitual sleep and work patterns. The study was also limited by lack of data on fatigue or sleepiness during the day. Sufficient sleep is individualized, and daytime fatigue symptoms would provide a more complete picture of how well rested nurses feel with respect to sleep duration and efficiency.

While ecological momentary assessment will ideally provide real-time information about nurses' symptoms, data was collected in the living and working environments. Nurses may not have been able to stop their task to respond to the text prompt immediately, resulting in delayed symptom reporting. Two nurses reported going to sleep prior to 9 p.m. one night, so they reported their end-of-day symptoms upon waking the following morning.

Because the sample is predominantly white, female nurses, all of whom resided in Texas and worked day shifts, the findings are not generalizable to a diverse nursing workforce across a broad geographic region. The results of this study should not be applied to nurses who work night shifts, rotating shifts, or who hold an administrative role. Additionally, these findings are only generalizable to nurses who are still healthy enough to work in a patient care role. This study is likely influenced by selection bias known as the Healthy Worker Effect [69], a phenomenon caused by excluding participants who are no longer healthy enough to work in patient care or who choose to work in non-patient care roles. Because the nurses in this study were able to meet the physical demands of direct patient care, they may be disproportionately healthy compared to the total population of nurses. The nursing workforce includes nurses in administrative, case management, quality assurance, education, and research roles, all of which are less physically demanding than direct patient care. Nurses in non-patient care roles may have different work, sleep, and musculoskeletal symptom patterns than those in direct patient care.

Sleep represents a critical physiological recovery process, though we acknowledge it is one component of a broader recovery framework that includes nutrition, physical activity, psychological restoration, and time away from work demands. Additional variables that influence MSS and sleep were not assessed. For example, job-related tasks and patient case load would have provided a more detailed picture of job demand. Personal factors such as family responsibilities and length of commute to the workplace may also influence MSS and sleep; however, they were not included in this study. Finally, the investigators did not screen or control for sleep disorders, such as sleep apnea.

4.3. Future Research

Longitudinal or case-control studies may better explain the cause-and-effect relationship between sleep and MSS. More research exploring the quantity of sleep needed for musculoskeletal recovery after a workday, and examining the MSS symptoms associated with fatigue and sleepiness is needed. Future research should assess daytime sleepiness, fatigue, and perceived recovery to differentiate between individual sleep duration needs. Future studies should also explore the relationship between MSS and cumulative sleep debt across consecutive shifts. To obtain a clearer picture of Total Worker Health in nurses, future studies should also explore the relationship between MSS and sleep while controlling for job demand, job control, sleep disorders, and personal stressors such as family responsibilities. A larger, more representative sample of nurses is needed to analyze additional variables in a multifactorial model without overfitting the data.

Because nursing is a 24-h profession, future research might focus on the relationship between MSS and sleep in nurses who work night shifts or rotating shifts. The standard of

practice for patient handling-related musculoskeletal injury prevention among healthcare workers is Safe Patient Handling and Mobility (SPHM) Programs [5–9]; however, MSS prevalence remains high [10] and sleep may be a contributing factor. The next step in translating this research into clinical practice is to examine the influence of sleep hygiene on the quality and effectiveness of SPHM programs for musculoskeletal injury prevention in nurses. For example, interventional studies might employ feedback from wearable devices to modify sleep behaviors while assessing MSS with ecological momentary assessment. Personalized feedback from wearable devices, combined with organizational schedule optimization, could empower nurses to make informed decisions about their health while alerting managers to systemic fatigue risks.

4.4. Implications for Occupational Health Policy

Sleep is an individual health behavior that is influenced by organizational characteristics and public policies [19,70]. Nursing organizations and regulatory agencies partially address sleep and fatigue in nurses; however, the risk to patient safety and nurse well-being warrant a more comprehensive Fatigue Risk Management Plan [31–33]. Several regulatory and professional organizations partially address nurse fatigue, but the current literature does not indicate the existence of a Fatigue Risk Management Plan for the United States nursing profession.

The American Academy of Nursing (AAN) recommends innovative work schedules that avoid shifts longer than 12 h for day shifts and no longer than 8 h for night shifts [32]. The AAN also recommends at least 10 continuous hours off work daily to support adequate sleep and recovery, as well as reviewing future work schedules for fatigue-related risk patterns [32].

The Joint Commission, a non-governmental accrediting organization focused on patient safety and quality care [71], recognizes the link between health care worker fatigue and adverse patient care events [33]. In addition to guidance on shift length, consecutive shifts, and time off shift, The Joint Commission recommends involving employees in schedule design, promoting sleep hygiene education, and fostering a safety culture that supports reporting fatigue concerns, especially when investigating sentinel events [33].

The Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) recommend that employers examine staffing and schedule adequate rest breaks and sleep opportunities. OSHA also recommends employers provide training on fatigue-related hazards, their impact on worker health, and the importance of sleep quality and quantity [31,34]. NIOSH provides more detailed recommendations for nurses who work shift work and long hours, including work scheduling strategies, napping, and balancing work and personal life [34].

The Joint Commission, AAN, and OSHA, and NIOSH all advocate for the implementation of a Fatigue Risk Management Plan; however, public policy does not currently mandate a Fatigue Risk Management Plan for nurses or healthcare professionals. The Joint Commission, AAN, and OSHA recommend a Fatigue Risk Management Plan modeled after systems used in the aerospace and aviation industries because they set the standard for occupational health policy and regulatory standards in fatigue risk mitigation [31–33]. The Federal Aviation Administration (FAA) and the National Air Traffic Controllers Association have adopted mandatory fatigue management measures for air traffic controllers that include at least 10 h off between shifts, 12 h off before and after midnight shifts, and limiting the number of consecutive shifts [72]. The Joint Commission recommends techniques used by the National Aeronautics and Space Administration (NASA), including strategic caffeine use, short naps (under 45 min), physical activity, and engaging in conversations [33]. How-

ever, NASA emphasizes that the only true prevention for fatigue-related adverse events is obtaining adequate quality and quantity of sleep [73].

Nurses in this study work in Texas, where no legal limits on nurse work hours exist. Also, the Fair Labor Standards Act (FLSA) does not cap weekly work hours but prohibits mandatory overtime that threatens health or safety [74]. Nurses commonly work twelve-hour shifts, which offer more days off, reduced commuting, improved patient care continuity, and fewer workflow interruptions [75]. However, drawbacks of twelve-hour shifts include increased risk of patient care errors, reduced mental capacity, reduced recovery time, diminished personal time on workdays, and higher rates of job fatigue which leads to burnout [75]. Fatigue tends to worsen across consecutive 12-h shifts [76], and in this study, higher musculoskeletal symptom intensity was linked with less sleep. Although evidence supports shorter shifts as beneficial for both patients and nurses at the organizational level, such changes may face resistance from individual nurses [77].

5. Conclusions

This study contributes objective evidence to the growing recognition of insufficient sleep among nurses and its association with increased musculoskeletal symptoms. These findings highlight the need for systemic interventions that address occupational barriers to adequate rest while protecting nurse well-being and enhancing patient safety. Additional studies of organizational strategies, such as self-scheduling, shorter shifts, and increased recovery time between shifts, may highlight whether a Fatigue Risk Management Plan will mitigate risks for musculoskeletal symptoms. Additionally, ethically implemented tools, such as wearable activity monitors, can support personalized sleep behavior change [68]. As fatigue continues to threaten the health of nurses and the safety of patients, policy makers and healthcare leaders must act—prioritizing sustainable work environments that protect the providers and the people they serve.

Author Contributions: Conceptualization, S.L., D.D. and L.P.; methodology, S.L., D.D., B.Y.C., B.F., R.P. and L.P.; formal analysis, S.L. and B.Y.C.; investigation, S.L., D.D., B.Y.C., B.F., R.P. and L.P.; resources, S.L. and D.D.; data curation, S.L. and B.Y.C.; writing—original draft preparation, S.L.; writing—review and editing, S.L., D.D., B.Y.C., B.F., R.P. and L.P.; visualization, S.L.; supervision, D.D.; project administration, S.L.; funding acquisition, S.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Texas Physical Therapy Foundation 2024 Research Grant.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the University of the Incarnate Word (protocol code 2023-1397-EXP on 18 May 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets presented in this article are available upon request from the corresponding author.

Acknowledgments: The authors thank the University of the Incarnate Word School of Rehabilitation Sciences for providing ActiGraphs and ActiLife software for this project.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

MSS	Musculoskeletal Symptoms
AAN	American Academy of Nursing
LLC	Limited Liability Corporation

M	Mean
SD	Standard Deviation
OSHA	Occupational Safety and Health Administration
NASA	National Aeronautics and Space Administration
FAA	Federal Aviation Administration
FLSA	Fair Labor Standards Act

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