Differences between fixed day shift nurses and rotating and irregular shift nurses in work-related musculoskeletal disorders: A literature review and meta-analysis

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Abstract
Objectives: Work-related musculoskeletal disorders (WMSDs) are common occupational injuries for nurses. Furthermore, rotating and irregular shift work may exacerbate muscle tension and pain in nurses. The objective of this study was to examine the differences between fixed day shift (FDS) nurses and rotating and irregular shift (RS + IS) nurses in WMSDs using a systematic literature review and meta-analysis.

Methods: Databases including PubMed, CINAHL, Cochrane Library, EBSCOhost, and Google Scholar were searched for relevant studies published between 2010 and 2020 using the target keywords.

Results: This study obtained data on a total of 18 199 nurses, among which 12 786 comprised the RS + IS group and 5413 constituted the FDS group. The result of the heterogeneity test was $Q = 79.27 (P < .001)$ and $I^2 = 57.11\%$, indicating that heterogeneity existed among the studies. Subgroup analyses were also conducted with four groups: neck pain ($n = 1818$), shoulder and upper limb pain ($n = 2525$), back pain ($n = 11962$), and hip and lower limb pain ($n = 1894$). Significant differences were found between the RS + IS group and the FDS group with regard to back pain, with the forest plot presenting an odds ratio equaling 1.40 (95% CI: 1.19–1.64, $P < .001$).

Conclusions: This meta-analysis indicated that RS + IS nurses are more likely to experience back pain associated with WMSD than are FDS nurses. The results can serve as a reference to the clinical management for work improvement and thereby reduce or prevent the adverse effects of rotating and irregular shift work on back pain experienced by nurses.

Keywords
fixed day shift, meta-analysis, non-standard work hours, nurse, rotating and irregular shift, work-related musculoskeletal disorder
1 | INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) are common occupational injuries. Clinical nursing is a physically demanding work as nurses must take care of patients and meet operational needs. In the long term, the physiological load of nursing often leads to WMSDs. Smith et al investigated WMSDs in 206 Chinese nurses during the previous year and found that 70% of those nurses suffered from WMSDs, most of which consisted of discomfort in the lower back. In contrast, Trinkoff et al surveyed nurses in Illinois and New York, USA, places which are known for ethnic diversity, and found that among 1163 nurses, 74% expressed having moderate or severe musculoskeletal pain in the neck, shoulders, or back, in which the discomfort persisted for at least 1 week per month in the past year. The nurses had sought help from doctors and took medication such as analgesics, skeletal muscle relaxants, and steroids. Furthermore, some of the nurses lost their motivation for work, recreation, or non-work activities and in severe cases, quit their job. WMSDs in nurses are mainly caused by shifting patients (which includes helping patients turn over or get in and out of bed), routine treatments in nursing, poorly designed work environments, and remaining active for prolonged periods of time. The physiological loads created by these nursing activities are all risk factors of WMSDs in nurses.

Clinical nurses must deal with daily routine work in busy wards, patient care and treatment, and correspondence for various matters. Their jobs are time-consuming, complicated, and full of stress, and they are often on tight schedules, all of which are associated with WMSDs.

Moreover, nurses must often work shifts, defined as work that is not fixed day shifts (FDSs). Aside from the conventional rotating shift work involving two or three shifts, fixed night shifts and/or evening shifts are also broadly regarded as rotating shift work. Working rotating and irregular shifts, which causes the physiological burden of disrupted circadian rhythms in the body, may also exacerbate muscle tension and pain.

Nurses are prone to WMSDs in the lower back, shoulders, neck, back wrists, knees, and angles. Trinkoff et al investigated the correlation between nursing staff scheduling and WMSDs and discovered that nurses working shifts aside from the day shift felt musculoskeletal discomfort in at least one of three places: neck, shoulder, and back. Another large-scale longitudinal study discovered that the odds ratios of nurses working rotating and irregular shifts and suffering from WMSDs in the neck, shoulders, and back were, respectively, 1.18, 1.29, and 1.27 times that of nurses not working rotating and irregular shifts. Thus, nurses have more occupational health concerns, and rotating and irregular shifts work renders nurses an occupation at high risk of musculoskeletal discomfort.

Caruso and Waters published a literature review that found inconsistent results in studies on the correlation between rotating and irregular shifts work and WMSDs. The objective of this study was to conduct a meta-analysis on literature published in the last decade to understand whether nurses working FDSs and rotating and irregular shifts experience differences in WMSDs in various parts of the body due to the time of their work shift. We aimed to understand the correlation between work shift and WMSDs in nurses working different types of shifts, and the study results can serve as a reference to formulate countermeasures to mitigate WMSDs.

2 | METHODS

The literature selection criteria in this study were as follows: peer-reviewed journal papers in English published between 2010 and 2020 and focusing on nurses (including midwives). The WMSDs collected in this study were defined as the fatigue, compression, and injury of muscle or surrounding tissue due to a part of the body bearing an excessive workload for prolonged periods of time, such that inflammation gradually amasses into unrecoverable musculoskeletal injury. There were no age nor gender restrictions; however, the studies had to include an RS + IS group and a FDS group as well as the numbers of nurses in these two groups with WMSDs due to the time of their work shift. We aimed to understand differences in WMSDs in various parts of the body among nurses working FDSs and rotating and irregular shifts. We aimed to understand the correlation between work shift and WMSDs in nurses working different types of shifts, and the study results can serve as a reference to formulate countermeasures to mitigate WMSDs.

2.1 | Selection criteria

The meta-analysis in this study complied with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework and ultimately included 17 studies. The keywords included in our search were musculoskeletal disorders, musculoskeletal pain, back pain, back disorders, neck pain, shoulder pain, rotating shift, night shift, and nurses. Using a combination of these keywords, 347 papers were obtained from relevant databases. After eliminating 29 duplicates, 318 studies remained. After reading the abstracts of these studies, another 290 studies that clearly did not fit our inclusion criteria were eliminated. The remaining 28 studies were then read to determine whether they fit the inclusion criteria. Of the 28 studies, 11 were eliminated for the following reasons, including not having an FDS group, also including other types of medical personnel, or not specifying...
where the WMSDs were. Figure 1 presents the literature collection process.

2.3 | Literature quality

The authors reviewed the studies obtained using one of the critical appraisal instruments developed by the Joanna Briggs Institute (JBI), which is an independent, international, non-profit research organization that has created a number of study review checklists to assess literature validity. The checklists are selected based on the research design of the study, and the content of the checklists revolves around sample representativeness, instrument reliability and validity, and appropriateness of statistical analysis. The JBI critical appraisal standards used for the observational studies in this study included the five following items: 1. whether the study was based on random or pseudorandom samples, 2. whether the criteria for inclusion in the sample were clearly defined, 3. whether outcomes were assessed using objective criteria, 4. whether sufficient descriptions of groups were given if comparisons were made, and 5. whether appropriate statistical analysis was used. The response for each item was “No”, “Yes”, or “Unclear”. Only “Yes” responses received 1 point; 0 points were given for any other response. Only studies with a total score of 4 or higher were included in the analysis. All 17 studies met the requirements and had good literature quality on the whole. For the credibility of the meta-analysis, a total of 17 studies (35 sets of data) were included in the analysis for the calculation of odds ratios (ORs). The appraisal process was independently completed by the two authors, and then the results were cross compared to ensure the confirmability of the study results.

2.4 | Statistical analysis

Data analysis was performed using the software package Comprehensive Meta-Analysis (CMA) 3.0. The variance

FIGURE 1 Flowchart of literature search process
### Table 1: Summary of literature included in meta-analysis

| Authors (Years) | Location       | Design           | Gender | Age (M ± SD) | Definition of shift work                                           | Work attributes                                                                 |
|-----------------|----------------|------------------|--------|--------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------|
| Abou El-Soud et al (2014) | Egypt | cross-sectional | F      | 20–40 occupying 65.3% | Fixed night shifts or rotating among morning, afternoon, and night shifts | 70% in internal medicine and surgical wards                                      |
| Arsalani et al (2014) | Iran | cross-sectional | F/M    | 30–39 occupying 38% | Not fixed morning shifts                                           | 37.8% in internal medicine and surgical wards                                    |
| Attarchi et al (2014) | Iran | cross-sectional | F/M    | 32.2 (6.1) | Fixed night shifts or rotating among morning, afternoon, and night shifts | Not mentioned                                                                    |
| Buja et al (2013) | Italy | cross-sectional | F/M    | 38.04 (8.2) | Rotating among morning, afternoon, and night shifts or rotating between morning and afternoon shifts | Not mentioned                                                                    |
| Burdelak et al (2012) | Poland | cross-sectional | F      | 40–60 | Rotating shifts with night shifts in the rotation | Not mentioned                                                                    |
| Dlungwane et al (2016) | South Africa | cross-sectional | F/M    | 40–49 occupying 33% | Fixed night shifts | 49% in obstetrics and gynecology wards                               |
| Fujii et al (2019) | Japan | cross-sectional | F      | 35.8 (10.6) | Fixed night shifts | 76.5% in wards                                                      |
| Ibrahim et al (2019) | Malaysia | cross-sectional | F/M    | <30 occupying 59.5% | Rotating among morning, afternoon, and night shifts | 70.3% in internal medicine department                                      |
| June and Cho (2010) | Korea | cross-sectional | F/M    | 27.2 (4.3) | Night shifts at least 6 days a month | ICUs only                                                                   |
| Mekonnen (2019) | Ethiopia | cross-sectional | F/M    | 31.39 (7.01) | Not mentioned | Not mentioned                                                        |
| Ovayolu et al (2014) | Turkey | cross-sectional | F/M    | 26–33 occupying 62.3% | Not fixed morning shifts | ICUs only                        |
| Raeisi et al (2014) | Iran | cross-sectional | F/M    | 32.4 (6.7) | Any shifts outside of period from 7:00 in the morning to 6:00 in the evening | Not mentioned                                                                 |
| Samaei et al (2017) | Iran | cross-sectional | F/M    | 33.6 (3.18) | Rotating among morning, afternoon, and night shifts | No restrictions                                                             |
| Shaﬁezadeh (2011) | Iran | cross-sectional | F/M    | 30–40 occupying 50.6% | Rotating among morning, afternoon, and night shifts | No restrictions                                                             |
| Yao et al (2019) | China | cross-sectional | F/M    | 28.9 (5.6) | Rotating shifts with night shifts in the rotation | 49.3% in internal medicine and surgical wards                               |
| Zhang et al (2019) | China | cross-sectional | F/M    | 31.1 (7.6) | Not fixed morning shifts | Ambulance nurses                                                        |
| Zhao et al (2012) | Australia | longitudinal | F/M    | 43.4 (9.9) | Not fixed morning shifts | No restrictions                                                             |

*Note: Abbreviation: Female, F; Male, M; Mean, M; Standard Deviation, SD.*
| Category of location | Authors (Years) | Observation period | Location | RS + IS | FDS |
|----------------------|----------------|-------------------|----------|---------|-----|
|                      |                |                   | Total    | No. With pain | Total | No. With pain |
| Neck                 | Arsalani et al (2014) | <1 week          | Neck     | 415     | 112 | 100 | 27 |
|                      | Attarchi et al (2014) | <12 months       | Neck     | 292     | 137 | 162 | 63 |
|                      | Shafiezezadeh (2011) | <12 months       | Neck     | 120     | 73  | 37  | 28 |
|                      | Yao et al (2019)   | <12 months       | Neck     | 510     | 366 | 182 | 106 |
| Total                |                 |                   |          | 1337    | 688 | 481 | 224 |
| Shoulder & upper limbs | Attarchi et al (2014) | <12 months       | Shoulder | 292     | 132 | 162 | 59 |
|                      | Attarchi et al (2014) | <12 months       | Elbow    | 292     | 55  | 162 | 33 |
|                      | Attarchi et al (2014) | <12 months       | Wrist    | 292     | 118 | 162 | 51 |
|                      | Shafiezezadeh (2011) | <12 months       | Shoulder | 120     | 55  | 37  | 16 |
|                      | Shafiezezadeh (2011) | <12 months       | Elbow    | 120     | 14  | 37  | 9  |
|                      | Shafiezezadeh (2011) | <12 months       | Wrist    | 120     | 57  | 37  | 23 |
|                      | Yao et al (2019)   | <12 months       | Shoulder | 510     | 292 | 182 | 86 |
| Total                |                 |                   |          | 1746    | 723 | 779 | 277 |
| Back                 | Abou El-Soud et al (2014) | <12 months       | Lower back | 95      | 76  | 55  | 43 |
|                      | Arsalani et al (2014) | <1 week          | Lower back | 415     | 165 | 100 | 39 |
|                      | Attarchi et al (2014) | 12 months        | Upper back | 292     | 146 | 162 | 68 |
|                      | Attarchi et al (2014) | 12 months        | Lower back | 292     | 182 | 162 | 79 |
|                      | Buja et al (2013)  | 12 months        | Back     | 394     | 339 | 46  | 34 |
|                      | Burdelak et al (2012) | 12 months       | Back     | 354     | 163 | 371 | 179 |
|                      | Dlungwane et al (2018) | <1 week          | Lower back | 242     | 119 | 242 | 123 |
|                      | Fujii et al (2019) | <4 weeks         | Lower back | 2334    | 1418 | 722 | 375 |
|                      | Ibrahim et al (2019) | <12 months       | Lower back | 1071    | 819 | 221 | 170 |
|                      | June and Cho (2010) | <12 months       | Lower back | 1022    | 934 | 323 | 280 |
|                      | Mekonnen (2019) | <12 months        | Lower back | 329     | 227 | 89  | 39 |
|                      | Ovayolu et al (2014) | >1 month         | Lower back | 73      | 61  | 41  | 35 |
|                      | Raeisi et al (2014) | <12 months       | Lower back | 341     | 219 | 191 | 98 |
|                      | Samei et al (2017) | <12 months       | Lower back | 205     | 145 | 38  | 24 |
|                      | Shafiezezadeh (2011) | <12 months       | Upper back | 120     | 54  | 37  | 12 |
|                      | Shafiezezadeh (2011) | <12 months       | Lower back | 120     | 58  | 37  | 20 |
|                      | Zhang et al (2019) | <12 months       | Lower back | 189     | 60  | 309 | 45 |
|                      | Zhao et al (2012) | <12 months       | Lower back | 456     | 174 | 472 | 145 |
| Total                |                 |                   |          | 8344    | 5359 | 3618 | 1808 |
| Hip & lower limbs    | Arsalani et al (2014) | <1 week          | Knee     | 415     | 142 | 100 | 40 |
|                      | Attarchi et al (2014) | <12 months       | Knee     | 292     | 151 | 162 | 69 |
|                      | Attarchi et al (2014) | <12 months       | Ankle    | 292     | 105 | 162 | 43 |
|                      | Shafiezezadeh (2011) | <12 months       | Hip      | 120     | 35  | 37  | 6  |
|                      | Shafiezezadeh (2011) | <12 months       | Knee     | 120     | 64  | 37  | 23 |
|                      | Shafiezezadeh (2011) | <12 months       | Ankle    | 120     | 49  | 37  | 12 |
| Total                |                 |                   |          | 1359    | 546 | 555 | 193 |
| Overall total        |                 |                   |          | 12 786  | 7316 | 5413 | 2502 |

Note: Abbreviation: Rotating shift, RS; Irregular shift, IS; Fixed day shift, FDS.
(heterogeneity or homogeneity) among the results of the 17 studies was examined using Cochran's Q test, and the relative importance and direction of the research outcomes of the studies were displayed using forest plots, with the fixed effect model or the random effect model to calculate the pooling OR. Sensitivity analysis was conducted to determine whether the elimination of any study would influence the overall results. Funnel plots were used to show whether the positive or negative effects of the various study results were as symmetric as a funnel, and Egger's regression was applied.

3 | RESULTS

3.1 | Overall analysis

This study obtained data on a total of 18,199 nurses, among which 12,786 comprised the RS + IS group and 5,413 constituted the FDS group. Tables 1 and 2 present the basic information and statistics of the nurses. The result of the heterogeneity test of the 17 studies (35 sets of data) was $Q = 79.27$ ($P < .001$) and $I^2 = 57.11\%$, indicating that heterogeneity existed among the studies. Subgroup analyses were also conducted to determine whether the RS + IS group and the FDS group displayed differences in the location of their WMSDs. Four groups were analyzed: neck pain ($n = 1,818$), shoulder and upper limb pain ($n = 2,525$), back pain ($n = 11,962$), and hip and lower limb pain ($n = 1,894$).

The sensitivity analysis indicated that the elimination of any study did not exert a significant impact on the pooling OR. $OR = 1.29$ (95% CI: 1.15–1.46, $P < .001$). The funnel plot was symmetric, thereby presenting no publication bias (Figure 2), and according to the linear regression (Egger's) analysis, $P = .187$, which means that there was no evidence indicating publication bias among the studies included in our meta-analysis.

3.2 | Subgroup analysis: neck pain

This analysis involved four sets of data. The results of the heterogeneity test were $Q = 9.69$ ($P = .021$) and $I^2 = 69.04\%$, both indicating that heterogeneity existed among the studies. Thus, the random effect model was chosen. The pooling OR presented by the forest plot was $1.18$ (95% CI: 0.77–1.82, $P = .440$), which did not reach the level of significance. This shows that RS + IS nurses were more likely to experience neck pain than were FDS nurses; however, the difference was not significant (Figure 3).

3.3 | Subgroup analysis: shoulder and upper limb pain

This analysis involved seven sets of data. The results of the heterogeneity test were $Q = 13.88$ ($P = .031$) and $I^2 = 56.78\%$, both indicating that heterogeneity existed among the studies. Thus, the random effect model was chosen. The pooling OR presented by the forest plot was $1.09$ (95% CI: 0.81–1.47, $P = .558$), which did not reach the level of significance. This shows that RS + IS nurses were more likely to experience shoulder and upper limb pain than were FDS nurses; however, the difference was not significant (Figure 3).

3.4 | Subgroup analysis: back pain

This analysis involved 18 sets of data. The results of the heterogeneity test were $Q = 44.26$ ($P < .001$) and $I^2 = 61.59\%$, both indicating that heterogeneity existed among the studies. Thus, the random effect model was chosen. The pooling OR presented by the forest plot was $1.40$ (95% CI: 1.19–1.64). This means RS + IS nurses were more
likely to experience back pain than were FDS nurses, and the difference was significant ($P < .001$) (Figure 3).

### 3.5 Subgroup analysis: hip and lower limb pain

This analysis involved six sets of data. The results of the heterogeneity test were $Q = 9.39$ ($P = .095$) and $I^2 = 46.73\%$, both indicating that heterogeneity existed among the studies. For this reason, the fixed effect model was chosen. The pooling OR presented by the forest plot was $1.23$ (95% CI: 0.99–1.52, $P = .060$). This shows that RS + IS nurses were more likely to experience hip and lower limb pain than were FDS nurses; however, the difference was not significant (Figure 3).

## 4 DISCUSSION

On the whole, the comparison of the RS + IS group and the FDS group in this meta-analysis indicated that more nurses
in the former group experienced WMSDs, particularly back pain. However, the differences between the two groups were not significant in terms of neck pain, shoulder and upper limb pain, or hip and lower limb pain.

In the 17 studies (35 sets of data) included in this meta-analysis, 11 sets of data indicated that RS + IS nurses suffered significantly more WMSDs than did FDS nurses.19,20,23,25,26,31–33 Some researchers believe that RS + IS nurses are prone to feeling fatigued, and work fatigue is a precursor to chronic muscle injury.34 Fatigue is a physiological condition resulting from an individual’s physical state and psychological cognition that disrupt the balance of the body’s internal environment.35 Two main causes result in fatigue: a lack of sleep and interrupted sleep cycles. Fatigue is the body’s response to a lack of sleep or long-term physical or mental effort. A lack of sleep or poor sleep quality not only causes fatigue, but it also slows responses at work, decreases alertness, impairs decision-making capacity, and leads to poor judgment as well as an inability to focus, all of which may result in endangerment and adverse consequences in the workplace.36 Work-related fatigue, such as lactic acid accumulation and reduced mobility in the muscles, lowers the endurance and load-bearing capacity of muscles, which is why fatigue is associated with a higher incidence of WMSDs.35,37 The core of the body’s biological clock is the suprachiasmatic nucleus of the hypothalamus, in which a number of nerve cells converge. From here, neural signals are transmitted directly to the pineal gland, which is affected by light from the day and night cycle. During the night, the pineal gland secretes high concentrations of melatonin, which causes drowsiness and maintains sleep.38 Because daily routines of FDS workers match their circadian rhythms, they can maintain an optimal mental state during work. On the contrary, RS + IS workers have irregular schedules. Owing to poor sleep environments and a daytime sleep period conflicting with their body’s sleep-wake cycle, RS + IS workers often have difficulty falling asleep, staying asleep, or sleeping restfully, which may result in a shortened duration of sleep. Moreover, deep sleep is crucial for reducing physical fatigue; however, RS + IS workers have substantially less deep sleep during the day and thus have difficulty feeling rested after sleeping.39–41 Thus, shift work is a crucial factor that influences the fatigue of nurses and may interfere with the steadiness of sleep.

The subgroup analyses in this study only found significant differences between the RS + IS group and the FDS group with regard to back pain. Among the 16 studies (18 sets of data) that examined back pain, eight sets of data indicated that RS + IS nurses were significantly more likely to experience back pain than were FDS nurses.19,20,23,25,26,28,32,33 The relative weight used in Fujii et al21 was 9.43% and higher than those used in the other 18 studies. A number of investigations

found that the most common location of WMSDs in nurses was in the back. Smith et al3 surveyed 180 nurses at a teaching hospital and discovered that approximately 70% experienced WMSDs, the most common being in the lower back (56.7%), upper back (38.9%), shoulders (38.9%), and neck (42.8%). Smith et al32 also investigated WMSDs in female nurses and found that the most common type was lower back pain (59.0%), followed by pain in the shoulder (46.6%), neck (27.9%), knees (16.4%), and upper legs (11.8%). Lipscomb et al43 derived a similar conclusion, with most instances of WMSDs in nurses being in the back.

Indeed, nursing work tends to cause back pain problems. If we look at the angle of trunk rotation from a biomechanical perspective, bad postures while shifting patients, lifting weights, or frequently bending over can put pressure on the spine and back muscles and in turn lead to back pain.44 However, there are no other existing meta-analysis studies on whether the fatigue caused by rotating and irregular shifts work exacerbates back pain problems. More meta-analysis studies will be needed to address this issue.

5 | CONCLUSION

A meta-analysis was conducted and found that RS + IS nurses are more likely to experience WMSDs than FDS nurses, particularly back pain. It is hoped that the results can provide reference to clinical management for work improvement and thereby reduce or prevent the adverse effects of rotating and irregular shift work on the health of nurses.

6 | STUDY LIMITATIONS

In addition to shift work, the factors influencing WMSDs may also include age, BMI, years of service, work hours, work department, birth history, and exercise habits. However, these factors could not be controlled in this meta-analysis, which may affect the inference results. Furthermore, the incidence of WMSDs requires longer periods of time to amass; however, most of the studies included in our meta-analysis were cross-sectional studies that collected data from a single time point. This made it difficult to determine whether a causal relationship exists between the rotating and irregular shift work of nurses and their WMSDs.

ACKNOWLEDGMENT

This research received no specific grant from any funding agency in the commercial or not-for-profit sectors.

CONFLICT OF INTEREST

The authors have no conflict of interest.
AUTHOR CONTRIBUTIONS
Wen-Pei Chang and Yu-Xuan Peng performed the literature search and helped write the manuscript; Wen-Pei Chang conceived and revised the article; and Wen-Pei Chang and Yu-Xuan Peng approved the final version of the manuscript.

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How to cite this article: Chang W-P, Peng Y-X. Differences between fixed day shift nurses and rotating and irregular shift nurses in work-related musculoskeletal disorders: A literature review and meta-analysis. *J Occup Health*. 2021;63:e12208. https://doi.org/10.1002/1348-9585.12208