RESEARCH ARTICLE

The role of circadian rhythm stability and amplitude in musculoskeletal disorder prevalence and work–family conflict

Majid Bagheri Hosseinabadi[1] | Narges Khanjani[2] | Jamal Biganeh[1] (iD) |
Mohammad Hossein Ebrahimi[3] | Erfan Pourhashemi[4] | Elnaz Roudi[5] | Akram Avarseji[6]

[1]School of Public Health, Shahroud University of Medical Sciences, Shahroud, Iran

[2]Environmental Health Engineering Research Center, Kerman University of Medical Sciences, Kerman, Iran

[3]Environmental and Occupational Health Research Center, Shahroud University of Medical Sciences, Shahroud, Iran

[4]School of Medicine, Shahroud University of Medical Sciences, Shahroud, Iran

[5]Department of Occupational Health Engineering, School of Health, Tehran University of Medical Sciences, Tehran, Iran

[6]School of Public Health, Zanjan University of Medical Sciences, Zanjan, Iran

Correspondence
Jamal Biganeh, School of Public Health, Shahroud University of Medical Sciences, Shahroud, Iran.
Email: jamal.biganeh@gmail.com

Funding information
Shahroud University of Medical Sciences, Grant/Award Number: 9788

Abstract

Aim: This study aimed to investigate the effect of circadian rhythm stability and amplitude on musculoskeletal disorder prevalence and work–family conflict among nurses.

Design: This cross-sectional study was conducted on 386 nurses working in three hospitals, in Shahroud, Iran.

Method: The data were collected using the Circadian Rhythm Inventory, Nordic Musculoskeletal Disorders, and Carlson Work-Family Conflict questionnaires.

Results: The highest prevalence of musculoskeletal disorders was reported in the lower back (68.4%), upper back (65.5%) and shoulders (53.6%), respectively. No significant relation was found between circadian rhythm stability and amplitude, and musculoskeletal disorders prevalence. The nurses who could not overcome drowsiness reported more Work Interference with Family (WIF), Family Interference with Work (FIW) (time-based) and FIW (strain-based) compared to the nurses who overcame drowsiness. In addition, the appropriate nurses for shift work experienced less WIF, FIW (behavioural-based) and WIF (strain-based) compared to the nurses who could not work overtime or at night.

KEYWORDS
circadian rhythm amplitude, circadian rhythm stability, family interference with work, musculoskeletal disorders, work interference with family

1 | INTRODUCTION

Nurses and other occupational groups usually work in shifts. As estimated, 15% to 30% of employees work in rotating shifts, including day, evening and night shifts (Boivin & Boudreau, 2014). However, shift work can enhance the risk of different diseases such as cardiovascular disease, metabolic syndrome, type 2 diabetes and respiratory infections by disrupting the circadian rhythm (Gan et al., 2015; Loef et al., 2019; Torquati et al., 2018). The International Agency for

Research on Cancer in 2007 classified shift work as a potential carcinogen (Group 2A) for humans (Straif et al., 2007). In addition, inactivity, smoking, overweight and poor diet are more common among shift workers than non-shift workers (Bekkers et al., 2015).

Musculoskeletal disorders (MSDs) are one of the most common health problems in nurses and are one of the main reasons for the nurses leaving their jobs and inability to continue their jobs (Bernal et al., 2015; Lin et al., 2020). A variety of factors such as sociodemographic aspects, psychological and physical situations can play

a role in the development of MSDs (Heiden et al., 2013; Rahman et al., 2017). Nurses are at high risk of MSDs because of sleep deprivation, burnout, stress, poor eating habits and lack of time for physical activity (Ferri et al., 2016; James et al., 2017).

Some studies have reported a higher prevalence of MSDs in shift working nurses in comparison to nurses working only at day shifts (Attarchi et al., 2014; Yan et al., 2017). However, in a review conducted by Caruso and Waters (2008), only eight of the 23 reviewed studies showed a significant increase in one or more MSDs among nurses, because of long working hours and shifts (Caruso & Waters, 2008). Furthermore, some researchers suggest that night, evening or rotation shifts are related to work–family interference, especially among females (Amelsvoort et al., 2004). Shift working may lead to work–family conflict through two pathways, strain-based conflict and time-based conflict (Iskra-Golec et al., 2017). Strain-based conflict means shift working increases nurses' exposure to stress such as lack of sleep, circadian rhythm disturbances and digestive disorders; and therefore, affects their ability to perform their roles in the family. Furthermore, the shift workers who work at night shifts have a different rest and work schedule from their family members, and this reduces the time they spend with family members (Greenhaus & Beutell, 1985; Iskra-Golec et al., 2016). Although some individuals work without any problem in unusual shifts like night and rotation shifts, others have to stop working in shifts because of their incompatibility (desynchronization) and its adverse health effects. Such interpersonal differences have made some individuals potentially more prone to the harmful effects of shift work (Reinberg & Ashkenazi, 2008). For this reason, it is important to consider individual differences in circadian rhythm stability and amplitude, while evaluating the detrimental effects of shift work, including the prevalence of musculoskeletal disorders and work–family conflict. The findings of different studies about the effect of shift work on musculoskeletal disorders and work–family conflict are controversial, and a small number of studies have shown a relation (Caruso & Waters, 2008; Iskra-Golec et al., 2017). Further, studies have not evaluated shifts and adaptability and have only categorized nurses based on shifts. This study aimed to investigate the relation between adaptation with shift working, by evaluating the relation between the stability and amplitude of circadian rhythm with the prevalence of musculoskeletal disorders and work–family conflict among nurses.

1.1 | Design

This cross-sectional study was conducted among nurses working in hospitals (Shahroud, Iran) from July to September 2019.

2 | METHODS

The target population included all nurses working at different wards of three hospitals in Shahroud, Iran ($N = 655$). Participants were selected based on the inclusion and exclusion criteria and after signing an informed consent form. The inclusion criteria were having a degree in nursing (undergraduate and postgraduate), working full-time at the hospital and having at least two years of work experience in nursing. The exclusion criteria were having musculoskeletal disorders caused by accident, having a second job and mental disorders, ageing, pregnancy and metabolic syndrome.

The sample size was calculated based on the rate of musculoskeletal disorders (69.5%) among Iranian nurses reported in previous studies (Samaei et al., 2017), the power of 0.8 and error of 0.03. The minimum calculated sample size needed was 380.

Nurses were selected by stratified random sampling method from various wards of the hospitals. We made a list of nurses who met the inclusion and exclusion criteria through their personal work history profiles and hospital job contracts. We excluded nurses who had MSDs caused by accidents or were pregnant. We also excluded the nurses who had metabolic syndrome based on the definition of World Health Organization for metabolic syndrome which is hyperinsulinaemia (the upper fourth of the fasting insulin level among nondiabetic subjects) or hyperglycaemia (fasting glucose ≥110 mg/dl) in addition to at least two of the following: waist ≥94 cm, dyslipidaemia (TG ≥150 mg/dl or HDL-C <40 mg/dl) or BP ≥140/90 mmHg (Balkau & Charles, 1999). This information was sought from the health records of the participants. After that, the participants were selected through personal IDs using stratified random sampling method.

420 questionnaires were distributed among nurses in different wards, and 386 questionnaires were returned, which means the response rate was 91.1%. The questionnaire included some questions about demographic information including age, sex, level of education, marital status, work experience and type of work shift, circadian rhythm stability and amplitude, musculoskeletal disorders and work–family conflict. Nurses were divided into two groups: nurses with rotating shifts (morning, evening and night) and nurses with fixed shifts (morning or evening). The nurses who were working with fixed shifts worked alternatively 1 week in morning shifts, and the next week in afternoon shifts, and never in night shifts. But nurses working in rotating shifts would work in different shifts (morning, afternoon and night) in each week. In other words, the nurses with rotating shifts were not able to sleep on some nights, but the nurses in fixed shifts had a normal sleep pattern.

2.1 | Circadian rhythm stability and amplitude

In this study, the Circadian Type Inventory questionnaire which was first developed by Folkard et al. and modified by Di Milia, Smith, and Folkard (Di Milia et al., 2005; Folkard et al., 1979) was used for determining the stability and amplitude of the circadian rhythm. The reliability and validity of the Persian version of the questionnaire were confirmed among Iranian nurses with a Cronbach's alpha of 0.76 (Hasheminejad et al., 2013). The circadian rhythm is a sine wave in a 24-hr period, in which stability is defined by the amount of variability by changing other parameters like the work–rest cycle, and amplitude indicates the maximum shift from a rest point, and in general, is described as wave

strength. This 11-item questionnaire describes the stability of the circadian rhythm as Flexible/Rigid and the amplitude of the circadian rhythm as Languid/Vigorous. The individuals with high scores on circadian rhythm stability are flexible, suitable for shift work and are able to stay awake during unusual hours of the day or night. In addition, those with high scores on the amplitude of the circadian rhythm are called Languid, and it is difficult for them to overcome drowsiness and they feel lethargic following reduced sleep. Therefore, people who are flexible (high stability score) and vigorous (low amplitude score) can adjust better with shift work. The 75th percentile is defined as Flexible and Languid on the stability and amplitude scales, and the 25th percentile is defined as Rigid and Vigorous. Percentages between 75 and 25 are classified in the Middle group (Di Milia et al., 2005).

2.2 | Musculoskeletal disorders

We used the Nordic Musculoskeletal Questionnaire to define the occurrence of pain in different parts of the body. This is a self-report, valid and reliable assessment tool that has been widely used to determine the prevalence of MSDs in divergent job groups, in particular nurses (Fang et al., 2013; Pugh et al., 2015). A diagram was used for showing nine parts of the body including the neck, shoulders, hands/wrists, elbows, upper back, lower back, hips, knees and ankles/feet. The reliability and validity of this questionnaire in Persian were confirmed by Choobineh et al. (Choobineh et al., 2004).

2.3 | Work–family conflict

Work–family conflict was evaluated through a questionnaire by Carlson and Kacmar (2000). This questionnaire is a self-report tool with 18 items on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). These items include six family–work conflicts including Work Interference with Family (WIF) according to time, strain, behaviour, and Family Interference with Work (FIW) according to time, strain and behaviour. Time-based WIF and FIW happen when the demand for time for one role physically makes it impossible to satisfy the needs of another role. Strain-based WIF and FIW are role-induced strains, while the strain from one role interferes with the performance and responsibilities in another role. For instance, the employees suffering from depression or stress find it difficult to be an attentive spouses or responsible parent. Behavioural-based WIF and FIW occur when behaviour in one role may be inconsistent with the behavioural expectations in another role. The internal validity of this questionnaire was obtained using Cronbach's alpha, and was 0.84 (Rasooli et al., 2009).

2.4 | Statistical analysis

Descriptive statistics including frequency (percentage), mean (standard deviation) and median (interquartile range) for non-normal data were used to summarize demographic information, circadian rhythm

stability and amplitude, musculoskeletal disorders and work–family conflict. Equivalence of variance and normality of the data was determined using the Levene's and Kolmogorov–Smirnov tests. Chi-square and Kruskal–Wallis tests were used for determining the relation between musculoskeletal disorders (prevalence greater than 50%) and work–family conflict scales with circadian rhythm stability and amplitude, respectively. Multivariate linear regression (Backward) was used to find the most significant predictors of work–family conflict scales. In the regression model, variables with p-value less than .25 in independent t tests were entered in the final model. The R-square was used for assessing model fit. Furthermore, the predictors of MSDs were determined by using multivariate logistic regression (Backward) with adjusting for the demographic variables. Non-normal variables were normalized through a method proposed by Templetion (Templeton, 2011) in which the percentile rank of non-normal variables was computed, and then using the inverse normal distribution function in SPSS, these variables were transformed to normal variables. The variables with more than two groups were entered as categorical variables in the regression model. All statistical tests were performed using SPSS v24 software, at a significance level of 0.05 (confidence interval 95%).

2.5 | Ethical considerations

This study was approved by the ethics committee of Shahroud University of Medical Sciences (IR.SHMU.REC.1397.105). The researchers explained the objectives of the study to all participants and answered their questions. Furthermore, the email addresses and phone numbers of the researchers were given to all participants. Then, the participants signed a consent form. The individuals were assured that their information would be kept strictly confidential, and the questionnaires were collected anonymously. The participants could leave the study whenever they wanted.

3 | RESULTS

The demographic information of the participants is presented in Table 1. More than half of the individuals were in the 30–40 years age group (54.7%) and two-thirds of them had normal body mass index (66.6%). Most of the participants in this study worked in rotating shifts (60.9%).

The prevalence of musculoskeletal disorders reported in different body parts is presented in Figure 1. The maximum prevalence of these disorders was reported in the lower back, upper back and shoulder. The minimum prevalence was reported in the hips and ankles.

The distribution of musculoskeletal disorders that had a prevalence higher than 50% among the nurses under study is presented in Table 2, in circadian rhythm stability and amplitude subgroups. Based on the results, the amplitude of the circadian rhythm was related with upper back pain, with limited significance ($p < .1$).
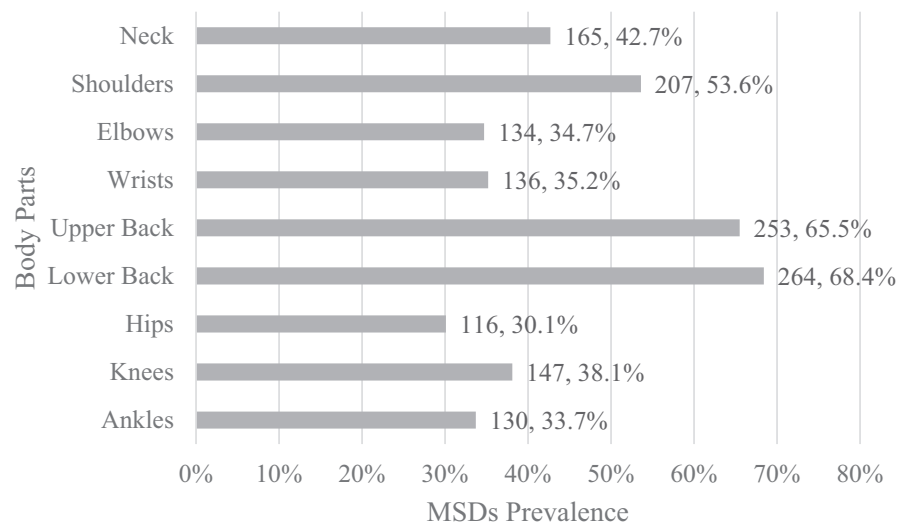
TABLE 1 Demographic information of the participants (N = 386)

Variables	Category	Frequency (%)
Age	>30	137 (35.5)
	30–40	211 (54.7)
	<40	38 (9.8)
BMI	Underweight	9 (2.3)
	Normal	257 (66.6)
	Obese	120 (31.1)
Gender	Male	80 (20.7)
	Female	306 (79.3)
Marital Status	Single	87 (22.5)
	Married	299 (77.5)
Shift work	Rotating	235 (60.9)
	Fixed	151 (39.1)
Position	Nurse	341 (88.3)
	Nurse Assistant	35 (9.1)
	Head-nurse	10 (2.6)

The results of backward multivariate logistic regression are showed in Table 3. Younger participants (less than 30 years of age) experienced more shoulder, lower back and upper back pain compared with older participants.

The relation between work and family conflict variables with circadian rhythm stability and amplitude is presented in Table 3. The nurses who were flexible and able to stay awake during unusual hours of the day or night experienced less strain-based WIF, and behavioural-based WIF than rigid individuals. Furthermore, time-based FIW and behavioural-based FIW were significantly higher among the nurses who were unable to stay awake during unusual day and night hours (Rigid), and also the nurses who were unable to overcome drowsiness.

The predictive variables of work–family conflict were specified using backward multivariate linear regression (Table 4). The results indicated that the nurses who could not overcome drowsiness experienced time-based work–family conflict. In addition, the individuals who could not stay up at night experience more behavioural-based, work–family conflict than flexible individuals (Table 5).

FIGURE 1 Prevalence of musculoskeletal disorders in participants over the past six months. The number of cases, and their percent have been shown at the end of each bar

Neck — 165, 42.7%
Shoulders — 207, 53.6%
Elbows — 134, 34.7%
Wrists — 136, 35.2%
Upper Back — 253, 65.5%
Lower Back — 264, 68.4%
Hips — 116, 30.1%
Knees — 147, 38.1%
Ankles — 130, 33.7%

Body Parts / MSDs Prevalence

TABLE 2 The distribution of MSDs with prevalence more than 50% based on circadian rhythm stability and amplitude

Variables	Classification	Shoulders		Upper Back		Lower Back	
		Yes	No	Yes	No	Yes	No
Stability	Rigid	68 (46.9)	77 (53.1)	96 (66.7)	48 (33.3)	97 (66.9)	48 (33.1)
	Middle	85 (65.4)	45 (34.6)	91 (69.6)	40 (30.4)	92 (70.8)	38 (29.2)
	Flexible	54 (48.6)	57 (51.4)	68 (61.5)	43 (38.5)	77 (69.4)	34 (30.6)
p-value[a]		.154		.753		.945	
Amplitude	Vigorous	111 (61.3)	70 (38.7)	133 (73.1)	49 (26.9)	125 (68.7)	57 (31.3)
	Middle	65 (46.1)	76 (53.9)	77 (54.6)	64 (45.4)	94 (66.2)	48 (33.8)
	Languid	33 (51.6)	31 (48.4)	45 (71.4)	18 (28.6)	45 (72.6)	17 (27.4)
p-value[a]		.264		.073		.849	

[a]Chi-square.

TABLE 3 The predictor variables of MSDs (with the prevalence higher than 50%). The demographic variables with p-value less than 0.25 in independent *t* tests were entered in the final model and adjusted for

Variable	Classification	β	95% CI Lower	Upper	P-Value
Shoulders	Age (<30 vs. 30–40)	−2.13	0.02	0.61	0.01
	Age (<30 vs. >40)	−1.62	0.04	0.98	0.047
	Gender (Female vs. Male)	−0.96	0.14	1.01	0.054
Upper Back	Age (<30 vs. 30–40)	−2.01	0.03	0.52	0.004
	Age (<30 vs. >40)	−1.2	0.08	1.09	0.068
Lower Back	Age (<30 vs. 30–40)	−2.25	0.02	0.42	0.002
	Age (<30 vs. >40)	−1.26	0.07	1.03	0.055

TABLE 4 The distribution of Work–Family Conflict according to the stability and amplitude of circadian rhythm. The first row shows mean ± SD, and the second row shows median (interquartile range)

Variables	Classification	Work Interference with Family			Family Interference with Work		
		Time	Strain	Behavioural	Time	Strain	Behavioural
Stability	Rigid	7.4 ± 2.24 7 (4)	8.2 ± 2.83 8 (5)	8.7 ± 2.21 9 (3)	7.8 ± 2.26 7.5 (3.3)	8.8 ± 2.81 9 (4)	8.3 ± 2.53 8 (3)
	Middle	7.8 ± 2.32 7.5 (4)	8.3 ± 2.43 8 (3)	8.8 ± 2.72 10 (4)	8.1 ± 2.52 8 (3.3)	7.8 ± 2.46 8 (2)	8.6 ± 2.47 9 (2.8)
	Flexible	6.9 ± 3.11 7 (5.5)	6.6 ± 2.94 6 (5)	7.4 ± 2.98 7 (4)	6.4 ± 2.72 6 (5)	7.2 ± 2.69 7 (4)	6.3 ± 2.46 6 (4)
p-value[a]		.278	.013	.02	.026	.019	0.001
Amplitude	Vigorous	5.3 ± 3.2 3 (4.5)	5.3 ± 2.73 4 (4.5)	7.1 ± 3.26 6 (6)	5.3 ± 2.95 3 (5)	6.4 ± 3.48 5 (6.5)	6.1 ± 2.66 6 (5)
	Middle	7.9 ± 2.75 8 (4)	8.3 ± 3.01 8 (5)	9.1 ± 2.62 9 (4)	8.1 ± 2.69 8 (3)	8.4 ± 2.71 8 (3.8)	8.2 ± 2.61 8 (3)
	Languid	7.6 ± 1.87 7 (3)	8.1 ± 2.33 8 (3.3)	8.2 ± 2.41 8 (3)	7.6 ± 2.01 8 (3)	8.1 ± 2.38 8 (3)	7.9 ± 2.52 8 (4)
p-value[a]		.002	.001	.068	.003	.059	.017

[a]Kruskal–Wallis.

4 | DISCUSSION

In this study, the effects of circadian rhythm stability and amplitude on the prevalence of musculoskeletal disorders and work–family conflict were evaluated. Since shift work is very common among nurses, and some of them may find it difficult to adjust to shift work schedules, they may be more vulnerable to occupational disorders (Bagheri Hosseinabadi et al., 2019). The results of this study reported that the maximum prevalence of musculoskeletal disorders was in the lower back, upper back, shoulders and neck among nurses; and the minimum prevalence was in the hips and ankles. In addition, no significant relation was found between circadian rhythm stability and amplitude, and the prevalence of musculoskeletal disorders. Based on the results of multivariate logistic regression, age was the only predictor variable for the prevalence of MSDs in the shoulders, and upper and lower back. Similarly, Yao et al., (2019) reported that the prevalence of musculoskeletal disorders during the last 12 months in nurses of five Chinese public hospitals was higher in the neck (68.2%), low back (67.6%) and shoulders (54.6%), respectively; and the minimum prevalence of musculoskeletal disorders was reported

in the elbows, with 17.3% (Yao et al., 2019). Saberipour et al. (2019) conducted a review study on musculoskeletal disorders prevalence among Iranian nurses and indicated that the prevalence of low back pain was 60%, and this was the highest prevalence reported in the 33 cross-sectional studies reviewed (Saberipour et al., 2019). A review by Caruso and Waters (2008) aimed at investigating the relation between extended and long shifts, and MSDs; and found that out of 23 studies, only eight studies showed a significant direct relation between long working hours and one or more MSDs; and concluded that because of the few studies and their incomparable methods, it is difficult to draw firm conclusions (Caruso & Waters, 2008). Similar to our results, Heiden et al., (2013) found that the prevalence of MSDS was higher in young nurses (age ≤ 35), than middle age (age 35–45) and older (≥45) nurses, but the only significant difference between the young and the middle age group was reported for shoulder pain (Heiden et al., 2013).

In the wards under study, the number of patients referred in the morning shift was significantly higher than the night and evening shifts, and most of the visits and medical examinations of patients were done in the morning shifts. These issues caused nurses to

TABLE 5 The predictor variables of Work–Family Conflict. The demographic variables with p-value less than 0.25 in independent *t* tests were entered in the final model and adjusted for

| Variable | Classification | β | 95% CI | | p-Value | R^2 |
			Lower	Upper		
Time-based WIF	Languid versus Vigorous	2.31	1.08	3.53	<.001	0.39
	Middle versus Vigorous	2.58	1.32	3.85	<.001	
Time-based FIW	Languid versus Vigorous	2.45	1.05	3.85	.001	0.38
	Middle versus Vigorous	2.85	1.41	4.28	<.001	
Strain-based WIF	Middle versus Vigorous	1.01	0.06	1.95	.036	0.32
	Rigid versus Flexible	1.22	0.11	2.34	.033	
	Middle versus Flexible	1.17	0.02	2.33	.046	
Strain-based FIW	Languid versus Vigorous	2.15	0.91	3.39	.001	0.34
	Middle versus Vigorous	2.39	1.11	3.67	<.001	
Behavioural-based WIF	Middle versus Flexible	1.85	0.81	2.91	.001	0.41
	Rigid versus Flexible	1.78	0.72	2.84	.001	
Behavioural-based FIW	Middle versus Vigorous	1.74	0.42	3.07	.01	0.45
	Rigid versus Flexible	1.37	0.48	2.26	.003	

experience more workload, stand for longer periods of time, have awkward postures and do more repetitive tasks during the morning shift. Such risk factors are the most significant causes of musculoskeletal disorders; but in this study, it was impossible to specify their effect on the prevalence of musculoskeletal disorders. This issue can be considered in future studies.

The findings of this study indicated that based on the multivariate linear regression model, the nurses who could not overcome drowsiness and were categorized in the languid group, and nurses in the middle group, had significantly more time-based WIF and FIW in comparison to nurses with vigorous circadian rhythms. Time-based work–family conflict happens when nurses are in their role, for instance in the family, but are mentally obsessed with occupational issues, or are unable to have an active presence in the family (Greenhaus & Beutell, 1985). The nurses who cannot deal with drowsiness, due to sleep problems, cannot play an effective role in spending time with their family and cannot create a time balance between work and family. In addition, the shift nurses experience work–family conflict in the long run, due to difficulties in coordinating their working time with other family members. Different studies have indicated that the main sources of time-based conflict in shift workers are the amount and number of long and rotating shifts, weekend work and work schedule inflexibility (Carlson & Kacmar, 2000; Greenhaus & Beutell, 1985). In addition, those who work evening and night shifts experience an inverted cycle of activity and rest pattern that limits the amount of time they spend in the family, resulting in time-based conflict (Greenhaus & Beutell, 1985). As a result, it seems that the more adaptable nurses are to the shift system, the better they can balance their work and family responsibilities and then, experience less work–family conflict.

In addition, the nurses whose circadian rhythm was appropriate for shift work and had the ability to overcome drowsiness had less strain-based WIF and FIW, respectively, than nurses who could not work during unusual day and night hours and overcome drowsiness.

Increased demand in one role prevents another from performing the role by creating strain through mechanisms including energy depletion, dissatisfaction, tension, anxiety and fatigue (Steiber, 2009). The nurses who cannot adapt to shifts and suffer from sleep disturbance experience strain-based conflict due to the depletion of individual resources needed to perform their role. Shifts, including night shifts, can disrupt the biological rhythm and social routine and result in sleep problems and health disorders. These factors create strain-based conflicts that result from stress in one area and lead to strains that affect the ability to perform tasks in another area.

Behavioural-based levels of WIF and FIW among the nurses with rigid circadian rhythm were significantly higher than nurses with flexible circadian rhythm. Behaviour-based conflict means the contradiction between the behaviours required to satisfy the distinct needs of the two roles (family and work). Nurses who cannot work during the unusual hours of the day and night, find it difficult to satisfy the behavioural needs of different roles. Shift work by disrupting the circadian rhythm usually causes sleep disturbances and they cannot communicate well with others while attending family gatherings, resulting in behavioural-based conflict.

Very few studies have been conducted on the extent of adaptation to circadian rhythms and work–family conflict, and only a few studies have evaluated the effect of shift work on work–family conflict. Mauno et al., (2015) indicated that Finnish shift working nurses experienced significantly more work–family conflict than non-shift workers (Mauno et al., 2015). In addition, Šimunić and Gregov (2012) reported that nurses working only in the morning shift experienced more work–family conflict compared to nurses working at all three shifts, including morning, evening and night (Šimunić & Gregov, 2012).

Nurses are at risk of MSDs and work–family conflict, but if their shift work schedules are based on their ability to cope with shift work, they will experience less consequences. However, the amplitude and stability of the circadian rhythm are often neglected in selecting shift

workers, and nurses who do not tolerate sleepiness suffer more from adverse health effects, especially work–family conflict.

This study had some limitations. One of them was that because all nurses were working in different shifts, we could not determine the shift that had the worst impact on work–family conflict and MSDs. Furthermore, we used a self-report questionnaire for assessing the presence of pain and discomfort, in this study. Therefore, nurses may have over-reported or under-reported their pain, when they filled the questionnaire. Therefore, we suggest that other researchers use more reliable diagnostic tests, such as electrodiagnosis for the assessment of MSDs, in future studies. We also suggest that workload, standing for long periods of time, awkward postures and repetitive tasks be considered as risk factors for MSDs among nurses, in future studies.

5 | CONCLUSION

This study indicated that the maximum prevalence of musculoskeletal disorders among nurses participating in the study was in the lower back, upper back and shoulders, respectively. The stability and amplitude of circadian rhythm were not significantly related to the prevalence of these disorders. However, the nurses who could overcome drowsiness and were appropriate for working in shifts and work at unusual hours had less work–family conflict compared to the nurses who felt drowsy following reduced sleep and were not suitable for shift work.

ETHICAL CONSIDERATIONS

This study was approved by the ethics committee of Shahroud University of Medical Sciences (IR.SHMU.REC.1397.105). In addition, the researchers explained the objectives of the study to all participants, and an informed consent form was signed by the participants. The individuals were assured that their information would be kept strictly confidential and they could leave the study without any problem, if they did not wish to continue.

AUTHOR CONTRIBUTIONS

JB and MBH: Study design. JB and ER: Data collection. NK: Data analysis. JB, EP and MBH: Manuscript writing. MHE and MBH: Revisions for important intellectual content.

DATA AVAILABILITY STATEMENT

Data available on request from authors.

ORCID

Jamal Biganeh [ID] https://orcid.org/0000-0002-2903-8200

REFERENCES

Attarchi, M., Raeisi, S., Namvar, M., & Golabadi, M. (2014). Association between shift working and musculoskeletal symptoms among nursing personnel. *Iranian Journal of Nursing and Midwifery Research*, *19*(3), 309–314.

Bagheri Hosseinabadi, M., Ebrahimi, M. H., Khanjani, N., Biganeh, J., Mohammadi, S., & Abdolahfard, M. (2019). The effects of amplitude and stability of circadian rhythm and occupational stress on burnout syndrome and job dissatisfaction among irregular shift working nurses. *Journal of Clinical Nursing*, *28*(9–10), 1868–1878. https://doi.org/10.1111/jocn.14778.

Balkau, B., & Charles, M. A. (1999). Comment on the provisional report from the WHO consultation. European Group for the Study of Insulin Resistance (EGIR). *Diabetic Medicine*, *16*(5), 442–443. https://doi.org/10.1046/j.1464-5491.1999.00059.x

Bekkers, M. B., Koppes, L. L., Rodenburg, W., van Steeg, H., & Proper, K. I. (2015). Relationship of night and shift work with weight change and lifestyle behaviors. *Journal of Occupational and Environmental Medicine*, *57*(4), e37–e44. https://doi.org/10.1097/JOM.0000000000000426.

Bernal, D., Campos-Serna, J., Tobias, A., Vargas-Prada, S., Benavides, F. G., & Serra, C. (2015). Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: A systematic review and meta-analysis. *International Journal of Nursing Studies*, *52*(2), 635–648. https://doi.org/10.1016/j.ijnurstu.2014.11.003

Boivin, D., & Boudreau, P. (2014). Impacts of shift work on sleep and circadian rhythms. *Pathologie Biologie*, *62*(5), 292–301. https://doi.org/10.1016/j.patbio.2014.08.001.

Carlson, D. S., & Kacmar, K. M. (2000). Work–family conflict in the organization: Do life role values make a difference? *Journal of Management*, *26*(5), 1031–1054. https://doi.org/10.1016/S0149-2063(00)00067-2.

Caruso, C. C., & Waters, T. R. (2008). A review of work schedule issues and musculoskeletal disorders with an emphasis on the healthcare sector. *Industrial Health*, *46*(6), 523–534. https://doi.org/10.2486/indhealth.46.523

Choobineh, A., Lahmi, M., Shahnavaz, H., Jazani, R. K., & Hosseini, M. (2004). Musculoskeletal symptoms as related to ergonomic factors in Iranian hand-woven carpet industry and general guidelines for workstation design. *International Journal of Occupational Safety and Ergonomics*, *10*(2), 157–168. https://doi.org/10.1080/10803548.2004.11076604

Di Milia, L., Smith, P. A., & Folkard, S. (2005). A validation of the revised circadian type inventory in a working sample. *Personality and Individual Differences*, *39*(7), 1293–1305. https://doi.org/10.1016/j.paid.2005.04.012.

Fang, Y., Li, S., Zhang, Y., Zhang, P., Wu, H., & Wang, D. (2013). Test-retest reliability of Nordic Musculoskeletal Questionnaire in nurses. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi= Zhonghua Laodong Weisheng Zhiyebing Zazhi= Chinese Journal of Industrial Hygiene and Occupational Diseases*, *31*(10), 753–758.

Ferri, P., Guadi, M., Marcheselli, L., Balduzzi, S., Magnani, D., & Di Lorenzo, R. (2016). The impact of shift work on the psychological and physical health of nurses in a general hospital: A comparison between rotating night shifts and day shifts. *Risk Management and Healthcare Policy*, *9*, 203–211. https://doi.org/10.2147/RMHP.S115326

Folkard, S., Monk, T. H., & Lobuan, M. C. (1979). Towards a predictive test of adjustment to shift work. *Ergonomics*, *22*(1), 79–91. https://doi.org/10.1080/00140137908924591.

Gan, Y., Yang, C., Tong, X., Sun, H., Cong, Y., Yin, X., & Gong, Y. (2015). Shift work and diabetes mellitus: A meta-analysis of observational studies. *Occupational and Environmental Medicine*, *72*(1), 72–78. https://doi.org/10.1136/oemed-2014-102150.

Greenhaus, J. H., & Beutell, N. J. (1985). Sources of conflict between work and family roles. *Academy of Management Review*, *10*(1), 76–88.

Hasheminejad, N., Sadeghi, M., Baneshi, M., Haji Maghsoudi, S., & Rastegari, A. (2013). Internal Consistency and Confirmatory Factor Analysis of Persian version Circadian Type Inventory in Iranian Day Worker and Shift Worker, 2011–2012. *Iran Occupational Health*, *10*(3), 45–51.

Heiden, B., Weigl, M., Angerer, P., & Müller, A. (2013). Association of age and physical job demands with musculoskeletal disorders in nurses. *Applied Ergonomics*, *44*(4), 652–658. https://doi.org/10.1016/j.apergo.2013.01.001.

Iskra-Golec, I., Barnes-Farrell, J., & Bohle, P. (2016). *Social and family issues in shift work and non standard working hours*. Switzerland: Springer.

Iskra-Golec, I., Smith, L., Wilczek-Rużyczka, E., Siemiginowska, P., & Wątroba, J. (2017). Shift schedule, work-family relationships, marital communication, job satisfaction and health among transport service shift workers. *International Journal of Occupational Medicine and Environmental Health*, *30*(1), 121–131.

James, S. M., Honn, K. A., Gaddameedhi, S., & Van Dongen, H. P. A. (2017). Shift Work: Disrupted Circadian Rhythms and Sleep-Implications for Health and Well-Being. *Current Sleep Medicine Reports*, *3*(2), 104–112. https://doi.org/10.1007/s40675-017-0071-6

Lin, S. C., Lin, L. L., Liu, C. J., Fang, C. K., & Lin, M. H. (2020). Exploring the factors affecting musculoskeletal disorders risk among hospital nurses. *PLoS One*, *15*(4), e0231319. https://doi.org/10.1371/journal.pone.0231319

Loef, B., van Baarle, D., van der Beek, A. J., Sanders, E. A., Bruijning-Verhagen, P., & Proper, K. I. (2019). Shift work and respiratory infections in health-care workers. *American Journal of Epidemiology*, *188*(3), 509–517. https://doi.org/10.1093/aje/kwy258.

Mauno, S., Ruokolainen, M., & Kinnunen, U. (2015). Work–family conflict and enrichment from the perspective of psychosocial resources: Comparing Finnish healthcare workers by working schedules. *Applied Ergonomics*, *48*, 86–94.

Pugh, J. D., Gelder, L., Williams, A. M., Twigg, D. E., Wilkinson, A. M., & Blazevich, A. J. (2015). Validity and reliability of an online extended version of the Nordic Musculoskeletal Questionnaire (NMQ-E2) to measure nurses' fitness. *Journal of Clinical Nursing*, *24*(23–24), 3550–3563. https://doi.org/10.1111/jocn.12971.

Rahman, H. A., Abdul-Mumin, K., & Naing, L. (2017). Psychosocial factors, musculoskeletal disorders and work-related fatigue amongst nurses in Brunei: Structural equation model approach. *International Emergency Nursing*, *34*, 17–22. https://doi.org/10.1016/j.ienj.2017.04.001.

Rasooli, P., Khankeh, H., Khoshknab, M. F., & Rahgozar, M. (2009). Effect of time management training on work-family conflict among hospital nurses. *Hayat*, *15*(3), 5–11.

Reinberg, A., & Ashkenazi, I. (2008). Internal desynchronization of circadian rhythms and tolerance to shift work. *Chronobiology International*, *25*(4), 625–643. https://doi.org/10.1080/07420520802256101.

Saberipour, B., Ghanbari, S., Zarea, K., Gheibizadeh, M., & Zahedian, M. (2019). Investigating prevalence of musculoskeletal disorders among Iranian nurses: A systematic review and meta-analysis. *Clinical Epidemiology and Global Health*, *7*(3), 513–518. https://doi.org/10.1016/j.cegh.2018.06.007.

Samaei, S. E., Mostafaee, M., Jafarpoor, H., & Hosseinabadi, M. B. (2017). Effects of patient-handling and individual factors on the prevalence of low back pain among nursing personnel. *Work*, *56*(4), 551–561. https://doi.org/10.3233/WOR-172526.

Šimunić, A., & Gregov, L. (2012). Conflict between work and family roles and satisfaction among nurses in different shift systems in Croatia: A questionnaire survey. *Archives of Industrial Hygiene and Toxicology*, *63*(2), 189–197. https://doi.org/10.2478/10004-1254-63-2012-2159.

Steiber, N. (2009). Reported levels of time-based and strain-based conflict between work and family roles in Europe: A multilevel approach. *Social Indicators Research*, *93*(3), 469–488. https://doi.org/10.1007/s11205-008-9436-z.

Straif, K., Baan, R., Grosse, Y., Secretan, B., El Ghissassi, F., Bouvard, V., Altieri, A., Benbrahim-Tallaa, L., & Cogliano, V., WHO International Agency For Research on Cancer Monograph Working Group. Carcinogenicity of shift-work, painting, and fire-fighting. *The Lancet Oncology*. 2007;8(12):1065–1066.

Templeton, G. F. (2011). A two-step approach for transforming continuous variables to normal: Implications and recommendations for IS research. *Communications of the Association for Information Systems*, *28*(1), 4., https://doi.org/10.17705/1CAIS.02804.

Torquati, L., Mielke, G. I., Brown, W. J., & Kolbe-Alexander, T. (2018). Shift work and the risk of cardiovascular disease. A systematic review and meta-analysis including dose-response relationship. *Scandinavian Journal of Work, Environment & Health*, *44*(3), 229–238. https://doi.org/10.5271/sjweh.3700

Van Amelsvoort, L. G., Jansen, N. W., Swaen, G. M., Van Den Brandt, P. A., & Kant, I. (2004). Direction of shift rotation among three-shift workers in relation to psychological health and work-family conflict. *Scandinavian Journal of Work, Environment & Health*, 149–156. https://doi.org/10.5271/sjweh.772.

Yan, P., Li, F., Zhang, L., Yang, Y., Huang, A., Wang, Y., & Yao, H. (2017). Prevalence of Work-Related Musculoskeletal Disorders in the Nurses Working in Hospitals of Xinjiang Uygur Autonomous Region. *Pain Research and Management*, *2017*, 5757108. https://doi.org/10.1155/2017/5757108

Yao, Y., Zhao, S., An, Z., Wang, S., Li, H., Lu, L., & Yao, S. (2019). The associations of work style and physical exercise with the risk of work-related musculoskeletal disorders in nurses. *International Journal of Occupational Medicine and Environmental Health*, *32*(1), 15–24. https://doi.org/10.13075/ijomeh.1896.01331.