An Updated Review of the Effect of Work Hours and Shift Work on Musculoskeletal Disorders with a Focus on the Healthcare Sector

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Abstract

Musculoskeletal disorders (MSD) are leading causes for sick days and long-term disability, and nurses are amongst the most affected. While long weekly work hours can increase MSD risk, the role of specific shift schedule characteristics in healthcare is poorly understood. For this narrative review, 236 abstracts published since 2008 were screened, and 15 retained manuscripts are summarized for an updated synthesis of the current evidence. In addition to long work hours, we identified night and shift work as MSD risk factors, the latter especially for low back pain. Some studies showed workload and individual factors as effect modifiers. Evidence for specific work schedule characteristics was often not available or of limited quality, hampering the ability to draw further conclusions.

Keywords: Nursing, Pain, Workload, Sleep, Working Time

Introduction

Musculoskeletal disorders (MSD) are widely recognized as a major contributor to overall disease burden in the population worldwide (Storheim/Zwart 2014), and nursing professions are amongst the most affected (Thinkhamrop et al. 2017), presumably due to their physically demanding work (Caruso/Waters 2008; NIOSH 1997). An early meta-analysis conducted by Hignett (1996) suggested that more frequent patient handling is a significant predictor of low back pain in nurses, which in turn represents an important predictor of physical disability.

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Overall, Hignett's analysis proposed that nurses have a lifetime prevalence of low back pain of 35-80%. In 2002, a survey by Trinkoff and colleagues in the US amongst 1,163 nurses showed that 74% reported moderate to severe musculoskeletal pain in neck, shoulders, or back for at least one week/month in the past year (Trinkoff et al. 2002). In a dataset from the New Zealand Census, out of 201 nurses, 58% reported MSD in the past 12 months, and 31% reported MSD symptoms in the past 7 days (Boocock et al. 2019). These numbers are higher than MSD symptoms in the general workforce. For example, 82% of hospital nurses in a German sample reported at least one MSD symptom as compared to 68% in the general workforce (BIBB/BAUA 2014). In view of the tight link between MSD and disability, there is growing concern of how to maintain a healthy nursing workforce, especially considering population trend projections and increasing demands for care (van der Heijden, Estryn-Béhar and Heerkens . 2019; Schmucker 2020).

Established MSD risk factors besides physical demands comprise older age, smoking, overweight/obesity, comorbidities, and psychosocial stress (Da Costa/Vieira 2010). In addition, work hours have also been identified as a risk factor for MSD in the nursing population. For example, a study by Lipscomb et al. (2002) examined the link between potentially demanding work characteristics and MSD in neck, shoulders, and back in a large US sample of about 1,300 nurses, and found that working full time, working days >8h, working 2-4 weekends/month, and working a schedule different from day shifts was associated with MSD symptoms in one or more body parts. In a review by Caruso/Waters (2008), they observed an increase of MSD reports with long work hours, even including a subgroup of studies that accounted for physical job demands. This clearly established work hours as an independent risk factor for MSD in nursing populations. Overall, the link between work hours and MSD is most robust for back pain, while data regarding neck and shoulder pain are less clear (Caruso/Waters 2008; Chang/Peng 2021).

However, studies with regards to shift work were inconclusive, mainly due to very crude exposure assessment. Other work hours-related exposures that remain poorly understood include quick returns, weekend work, overtime, and on-call or split schedules. And while a recent meta-analysis by Chang/Peng (2021) based on 17 studies and >18,000 individuals reported a 40% MSD risk increase for "irregular and shift working" nurses as compared to "day shift" nurses, recommendations for work schedule design remain inconclusive, due to their very basic definition of shift work: "Any fixed shift beginning between 7:00 and 9:00 in the morning was defined as FDS [fixed day shift]. All remaining shifts were defined as RS + IS [rotating shift + irregular shift]" (Chang/Peng 2021, p. 2). However, nursing will remain a 24/7 profession, and abolishment of rotating and irregular shifts per se is not an option. Our review aimed thus to identify evidence for specific shift work and work hours characteristics associated with MSD risk.

The mechanisms linking long work hours with MSD include extended exposure to high physical and psychosocial workload, and thus also potentially higher physical and psychosocial demands, as well as shortened sleep and rest opportunity that will increase need for recovery and result in fatigue (Caruso 2014). Indeed, a recent study by Park/Kim (2020) in more than 30,000 participants of the 5th Korean Working Conditions Survey, a representative survey conducted in 2017, showed that rest opportunities during work and a minimum of 11h break

between work end and work start on the next day is associated with less MSD symptoms (Park/Kim 2020). Shift and night work can result in additional strain and sleep deprivation (Åkerstedt 2003; Åkerstedt/Wright 2009; Caruso 2014; Folkard et al. 2005; Karhula et al. 2013) and thus might hamper recovery further (Moreno et al. 2019). Known downstream effects of shift work include elevated fatigue levels, higher accident and injury risk, and increased chronic disease risk (Costa 2003; Kecklund/Axelsson 2016; Moreno et al. 2019; Rajaratnam et al. 2013; Smith/Eastman 2012). Effects of shift work on sleep, health, and wellbeing will however depend on the exact work schedule characteristics (Arlinghaus et al. 2019; Fischer et al. 2016; Fischer, Roenneberg and Vetter 2021; Juda, Vetter and Roenneberg 2013; Kervezee et al. 2021; Vetter et al. 2015), and only such granular work hours information can then be used to guide prevention, intervention, and studies.

While the evidence discussed above indicates an important contribution of working hours and shift work to the risk of MSD, no recent study has evaluated the contribution of more specific work schedule characteristics to MSD risk, since the review by Caruso/Waters in 2008. The recent meta-analysis by Chang/Peng (2021) included more recent studies but was hampered by very broad definitions of shiftwork and work schedule characteristics. The goal of this study is therefore to synthesize the body of evidence on specific work schedule characteristics and MSD risk published since 2008. A secondary goal is to review the existing evidence regarding the effects of potential mediators of the association between work hours and MSD risk, such as psycho-social stress, workload (such as physical demand), sleep, and high BMI. Based on the existing literature, we expected that long work hours, shift work, and night work independently predict elevated MSD risk, by increasing psychosocial stress and physical demand, as well as adversely impacting sleep (Figure 1). Taken together, this study aims to shed light on exact work hours characteristics increasing MSD risk, as well as identifying potential pathways from work hours to MSD risk in healthcare. Both, a better understanding of specific hazardous work hours characteristics, as well as potential mediators of the link between work and MSD, will provide important guidance towards prevention efforts.

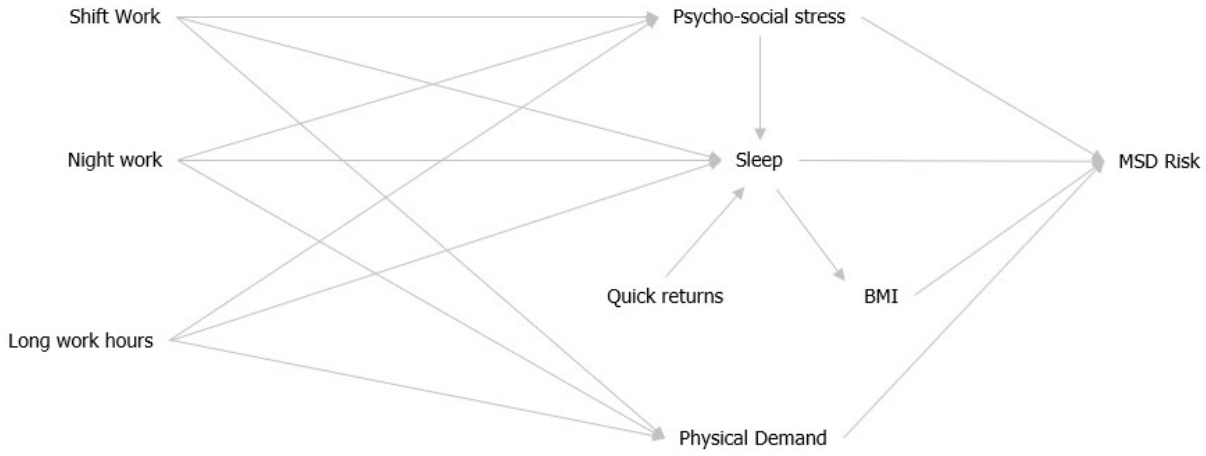

Figure 1. A directed acyclic graph (DAG, Tennant et al. 2021) of the theoretical relationships between work hours, demands, sleep and MSD risk.

Methods

This study was based on a systematic literature review, with the goal to identify peer-reviewed scientific manuscripts, published since as the work of Caruso/Waters was published in 2008. The literature review comprised a systematic search on www.pubmed.org with *a priori* defined search terms (see Table 1). The search string was based on Caruso/Waters literature search ("Key words used for the OVID search were shift$ ($ indicates search found all terms that started with the root term) and work$ or work$ and hour$, combined with musculosk$", p. 525). An extension was made to target specifically the healthcare nursing population. We obtained 224 hits with these search terms, for which all titles and abstracts were screened by AA. In addition, we conducted a GoogleScholar search on March 23rd 2021 to identify any manuscripts that might have been missed or published in the meantime (see Table 2 for search strings). This second search resulted in 12 additional studies that were not identified during the PubMed search. Inclusion criteria were: i) peer-reviewed articles (primary literature and review studies, if available); ii) healthcare sector; iii) musculoskeletal disease or musculoskeletal symptoms as outcome, and iv) abstract and full text available either in English or German language. Studies were excluded from the review if they were animal or laboratory studies but would be included in the discussion if appropriate for yielding mechanistic insights. Finally, studies were only retained if they were of sufficient quality. Quality assessment was determined based on reporting quality and using the STROBE criteria for observational research and were categorized as high, moderate to low, and insufficient quality (Von Elm et al. 2007). In case of ambiguity, an additional review of the manuscript was conducted by CV, and decisions were made consensus-based by AA and CV. Study quality was deemed as insufficient if either STROBE criteria were not fulfilled, study methods did not include statistical testing of associations, or exposure and/or outcome assessments were not described.

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(((((shift*[Title/Abstract]) AND
(work[Title/Abstract])) OR
(work*[Title/Abstract] AND
hour*[Title/Abstract]) AND
(Nurs*[Title/Abstract] OR
Hospital[Title/Abstract] OR
care*[Title/Abstract])) AND
(musculosk*[Title/Abstract])) AND
(("2007"[Date - Publication] :
"3000"[Date - Publication])))
```

Table 1. Search string for PubMed search conducted on March 11th 2021

- *"long work hours musculoskeletal disorders nursing"*
- *„shift work musculoskeletal disorders nursing"*
- *"long work hours musculoskeletal disorders home health aide"*
- *"shift work musculoskeletal disorders home health aide"*
- *„Schichtarbeit Pflege"*
- *„Arbeitszeit Pflege"*
- *„Pflege Muskel-Skelett"*

Table 2. Search string for Google Scholar search conducted on March 23rd 2021

Results

Screening of titles and abstracts according to the inclusion criteria listed above resulted in the retention of 75 peer-reviewed studies published after 2008. After a careful evaluation and review of the full-text manuscripts, 60 studies were excluded because they did not report work schedule variables or MSD outcomes, were outdated (e.g. review studies of literature prior to 2008), or did not report any statistical / quantitative analyses. In total, 15 studies were retained to inform this review article. Of those, 6 (40%) were of high quality, 7 of intermediate quality (46,7%), and 2 were of low quality (13,3%).

A total of 6 studies examined the association between long weekly or daily work hours and MSD (Cameron et al. 2008; Clari et al. 2019; Dong et al. 2020; Mekonnen 2019; Park et al. 2014; Yan et al. 2017), while a total of 12 studies examined shift and night work as exposure of interest (Attarchi et al. 2014; Bazazan et al. 2019; Bjorvatn et al. 2018; Cameron et al. 2008; Chang/Peng 2021; Katsifaraki et al. 2019, 2020; Kim et al. 2012; Matre et al. 2020; Mekonnen 2019; Yan et al. 2017; Zhao, Bogossian and Turner 2012). Note that some studies examined multiple dimensions of work schedules, and thus are used with regards to duration and timing of work hours. Here, we provide an overview of the directionality of evidence, study origin, sample size, and study quality for the included studies in relation to work schedule characteristics in Tables 3 and 4.

Long work hours and MSD risk

We identified three cross-sectional questionnaire studies examining the association between weekly work hours and MSD risk. In one study, over 30,000 hospital employees in China were queried, reporting 70% higher odds of neck and shoulder pain when employees worked 40-45h/week (OR 1.7, 95%CI 1.1-2.4) as compared to working up to 40h/week (Dong et al. 2020). Employees working 45h/week or more even had a more than two-fold risk increase (OR 2.3, 95%CI 1.4-3.5). These results accounted for workload in their statistical models. A study with

148 surgical nurses in Italy showed that nurses working fulltime (i.e., >120h/month) had a 3-fold risk increase for MSD in the upper body, as compared to nurses working part time. Workload was not accounted for; however, the authors statistically accounted for the surgical subspecialities (Clari et al. 2019). A large-scale Chinese study (N=6,674 across 16 hospitals) also reported that weekly work hours increased the risk of MSD symptoms (OR 1.4, 95%CI 1.2-1.6), after accounting for individual-level factors, such as self-reported health status and shift work. Note that no definition for weekly work hours was provided in this study (Yan et al. 2017).

A total of three cross-sectional studies examining the role of daily work hours with MSD risk were published after 2008. One study amongst 303 older nurses (average age: 51.5 yrs) included a questionnaire on MSD symptoms, pain intensity, and body location (Cameron et al. 2008). Nurses working 12h shifts reported of more frequent pain in the lower back, knees, and lower extremities, as compared to those not working 12h shifts. Workload was not quantified or adjusted for in this overall rather low-quality study. Another questionnaire-study amongst 422 nurses in Ethiopia showed that daily work hours of >8h were associated with MSD, after adjusting for overtime, stress levels, and shift work (Mekonnen 2019). Park et al. (2014) queried 265 employees of an elderly care home, asking for pain frequency, duration, and intensity. In this lower quality study, those working 12-24h shifts had lower odds of neck pain (OR 0.46, 95%CI 0.22-0.86) and lower extremities pain (OR 0.41, 95%CI 0.24-0.72).

Exposure	Study quality	Directionality of Association		
		+	o	-
Long weekly work hours (e.g. >40h/week)	**Intermediate to high**	**Dong et al. (2020),** China, N=29,547; **Clari et al. (2019),** Italy, N=148		
	Low	**Yan et al. (2017),** China, N=6,674		
Long daily work hours (10h- 12h shifts)	**Intermediate to high**		**Mekonnen (2019),** Ethiopia, N=422	
	Low	**Cameron et al. (2008),** Canada, N=303	**Park et al. (2014),** South Korea, N=265	
Split shifts	*No studies identified*			

Table 3. Overview of the included studies on work duration and MSD risk.

No studies could be identified with split shifts as exposure and musculoskeletal disease as outcome, despite their prevalence in the healthcare sector, warranting future research efforts.

Shift work and MSD risk

In total, we identified 10 studies examining the link between shift work and MSD risk published after 2008. A recent meta-analysis on shift work and MSD risk summarized results from 17 studies based on 18,199 nurses, of which 5,413 worked fixed day shifts, while the remaining participants engaged in shift or night work (Chang/Peng 2021). According to this meta-analysis, nurses working shifts had 40% higher odds of lower back pain (95%CI 1.19-1.64) compared to those working fixed day shifts. There was no significant association for neck or shoulder pain. These results are in line with those of a smaller, but high quality prospective study conducted in 926 nurses free of back pain at baseline (Zhao et al. 2012). After two years of follow-up, working in shift work was associated with an 15% risk increase for lower back pain (95%CI 1.05-1.40) as compared to working day shifts. It is noteworthy that shift work was not further defined in this study. This increase in risk was observed even after adjustment for patient care and workload. Furthermore, this study indicated that overweight and obese individuals were at even higher MSD risk, as compared to individuals with a body mass index (BMI) in the normal range. Results from the other, less methodologically rigid, manuscripts showed overall consistent associations between shift work exposure and lower back pain (Attarchi et al. 2014; Cameron et al. 2008; Mekonnen 2019; Yan et al. 2017).

Another large-scale study relying on a review of 3,400 insurance compensation claims in Korea also showed an association between evening shifts and MSD risk (Kim et al. 2012). However, this association was no longer significant after adjustment for physical workload, suggesting that patient handling may play a critical role in the link between shift work MSD. The insurance claim data did not capture actual but planned work hours, and this misclassification might have biased this association towards the null, and thus represent an underestimation of the link between shift work and MSD risk. Other studies did not report associations between shift work and specific MSD symptoms such as headaches (Bjorvatn et al. 2018), and neck or shoulder pain (Attarchi et al. 2014; Katsifaraki et al. 2019), or associations were attenuated after accounting for work load, especially with regards to patient handling.

Exposure to night work and MSD risk

Night work exposure has not been examined separately in the review by Caruso/Waters (2008), presumably due to a lack of studies. We identified a total of six manuscripts on night work and MSD risk published after 2008. A high-quality study conducted in Finland followed 679 shift-working nurses over 28 days, where participants were asked to log daily pain levels (Katsifaraki et al. 2020). Night work, as compared to early morning shifts, was associated with a significantly higher level of lower back (OR 1.73, 95% CI 1.02-2.92) and abdominal pain (OR 3.17, 95%CI 1.80-5.60). Based on that same dataset, the authors also observed an association between night work exposure and the reports of headaches and upper limb pain (Katsifaraki et al. 2019). In contrast, participants reported significantly less leg pain when working nights, as compared to day shifts (OR 0.39, 95%CI 0.22-0.69), which might be due to less physical demand and lower work density during the night shift in this population. If participants however reported short sleep durations, the odds of leg pain associated with night shift work increased, and this is true after adjustment for physical workload. Overall, despite of this dataset's high quality, this study also suffers from low participation, and might thus be biased.

Another study with 454 participants working in a hospital setting observed 95% higher odds of lower back pain amongst night workers, compared to day shift workers (Attarchi et al. 2014). This study considered individual MSD risk factors, such as age, sex, or smoking, but did not consider workload, which might have led to an overestimation of the true association. In addition, work hours were defined based on daylight availability during work hours, representing a rather crude and possible seasonally distorted exposure assessment. A third cross-sectional study including 380 nurses in Iran also reported higher MSD prevalence with higher symptom severity amongst night workers, as compared to day workers (Bazazan et al. 2019). This study also did not account for potential confounders, which might have affected the reliability of these results. In a fourth cross-sectional study of 1,585 nurses no relationship between night work and MSD symptoms was found (Matre et al. 2020). Another secondary data analysis based on this same questionnaire-based dataset showed that nurses working nights tended to report more chronic headaches, tension headaches, and medication-induced headaches, as compared to their colleagues working days (Bjorvatn et al. 2018). While some of the effect estimates indicated a relevant association, they were not statistically significant, which emphasizes the need for follow-up studies on this topic.

The study described above amongst Finnish nurses who were asked to log their pain levels on a daily basis also examined whether the association between night work and MSD symptoms depended on the number of night shifts (Katsifaraki et al. 2020). Katsifaraki and colleagues report indeed that risk of headaches was higher after the third night shift, as compared to the second one (OR 1.13, 95%CI 0.99-1.28), although the confidence intervals indicate that this observation was not statistically significant. When the authors considered sleep duration, this association was attenuated, indicating that the link between the number of night shifts and headache might be mediated, at least in part, through sleep deprivation, which is well known to accumulate with the number of consecutive night shifts (Fischer et al. 2021). Another study with 6,674 nurses showed a positive relationship between the number of night shifts and the odds of MSD (Yan et al. 2017). Compared to nurses not working nights, those who worked 1-5 night shifts/month had 2.6-times higher odds of MSD (OR 2.61, 95%CI 2.08-3.26), which

further increased with more frequent night shifts (6-9 nights/month: OR 3.65, 95%CI 2.94-4.54; 10 or more nights/month: OR 3.76, 95%CI 2.99- 4.73). This analysis considered potential confounders, such as age, sex, weekly work hours, and BMI. Despite these reports of higher MSD odds with increasing number of night shift exposures, two Norwegian questionnaire studies amongst 1,585 nurses reported null findings with regards to the link of night shift frequency with headaches (Bjorvatn et al. 2018) or general pain (Matre et al. 2020).

Exposure	Study quality	Directionality of Association		
		+	o	-
Shift work (reference: Day work)	**Intermediate to high**	**Chang/Peng (2021),** Meta-analysis, N=18,199 (back pain); **Zhao et al. (2012),** Australia, New Zealand and UK, N=928	**Chang/Peng (2021),** Meta-Analysis, N=18,199 (neck, shoulders, upper body, lower extremities); **Bjorvatn et al. (2018),** Norway, N=1,585; **Katsifaraki et al. (2019),** Norway, N=679; **Kim et al. (2012),** USA, N=3,452 insurance compensation cases (based on 24,824 full time equivalent)	
	Low	**Attarchi et al. (2014),** Iran, N=454 (back pain); **Cameron et al. 2008,** Canada, N=303; **Mekonnen (2019),** Ethiopia, N=422; **Yan et al. (2017),** China, N=6,674	**Attarchi et al. (2014),** Iran, N=454 (neck, upper body, hips, legs)	
Night shifts (reference: Day shifts)	**Intermediate to high**	**Bazazan et al. (2019),** Iran, N=380; **Katsifaraki et al. (2019),** Norway, N=679; **Katsifaraki et al. (2020),** Norway, N=679 (back and abdominal pain)	**Bjorvatn et al. (2018),** Norway, N=1,585; **Matre et al. (2020),** Norway, N=1,585	**Katsifaraki et al. (2020),** Norway, N=679 (lower extremities)
	Low	*No studies identified*		
Frequency of night shifts (for example per month or year)	**Intermediate to high**	**Bjorvatn et al. (2018),** Norway, N=1,585 (Tension headaches)	**Bjorvatn et al. (2018),** Norway, N=1,585 (other headaches); **Matre et al. (2020),** Norway, N=1,585; **Katsifaraki et al. (2020),** Norway, N=679	
	Low	**Yan et al. (2017),** China, N=6,674		

Rotational vs. permanent schedules (such as permanent night shift work)	**Intermediate to high**		**Bjorvatn et al. (2018),** Norway, N=1,585	
	Low	*No studies identified*		
Direction and speed of rotation of a given shift schedule	**Intermediate to high**	*No studies identified*		
	Low	*No studies identified*		
Irregular shifts	**Intermediate to high**	**Chang/Peng (2021)**, Meta-Analysis, N=18,199 (back pain);	**Chang/Peng (2021)**, Meta-Analysis, N=18,199 (upper body, neck, lower extremities);	
	Low	*No studies identified*		
On-call shifts	**Intermediate to high**	*No studies identified*		
	Low	*No studies identified*		
Quick returns (e.g., <11h between two shifts)	**Intermediate to high**		**Bjorvatn et al. (2018),** Norway, N=1,585 (other headaches); **Matre et al. (2020),** Norway, N=1,585; **Katsifaraki et al. (2020),** Norway, N=679	
	Low	*No studies identified*		

Table 4. Overview of included studies in relation to shift and night work and MSD risk.

Discussion

This narrative review summarizes the evidence on the relationship between work hours, shift work, and MSD published since 2008, with the goal to update our knowledge base since the review by Caruso/Waters (2008). Back then, Caruso and Waters reported that long work hours might contribute to increased MSD prevalence in nursing and healthcare professions, but the contribution of other work hour characteristics, such as shift and night work, was unclear. Our updated review is in line with Caruso and Waters' prior findings, in that long weekly work hours (>40h/week) increased the risk of neck and shoulder pain. The role of daily shift length however remains elusive. We identified 10 studies published since 2008 which showed that shift workers had an increased risk of lower back pain, as compared to nurses working the day shift. These findings extend the prior evidence on the effects of shift work in nursing. Results regarding night work also showed a tendency towards an increased MSD risk but were overall more mixed. In contrast, quick returns were not associated with an elevated MSD risk, but only limited evidence was available. Evidence regarding irregular shifts, permanent night shifts, split shifts, and shift schedule direction and speed was scarce or even not available and does therefore not enable reliable conclusions. Overall, this review strengthens the contribution of long work hours and shift work to MSD risk and highlights the need for future studies with detailed exposure assessment.

It is likely that the influence of work hours on MSD risk is mediated by their impact on known MSD risk factors such as high physical and psycho-social demands, sleep impairments

and high BMI, as shown in Figure 1. Physical workload has been identified as a major contributor to work-related MSD in nursing (Hignett 1996). Long work hours can lead to a prolonged exposure to high physical demands while reducing time for recovery and sleep. This elevates the risk both due to increased demands and impaired recovery, making cumulative negative effects over time more likely. It is noteworthy that long weekly work hours might go hand in hand with extended daily work hours, as an accumulation of 12h-shifts can easily result in weekly work hours of >40h.

Our findings with regards to night work were overall mixed, with some studies indicating an increased MSE risk for night work but no clear effects for the number of nights worked. While it is known that night work leads to a plethora of adverse psychosocial, behavioral, and physiological effects, it remains crucial for continuous patient care. Night work can on the one hand be less physically demanding, as it requires less patient handling, and might thus be less burdensome in terms of MSD risk. On the other hand, in some occupational settings night shifts may be very demanding. Additionally, sleep after night shifts is often of lower quality, shorter duration, and occurs outside of the nurses' biological night (e.g., Åkerstedt 2003; Drake et al. 2004; Juda et al. 2013; Sallinen/Kecklund 2010). Two of the studies cited in this review by Katsifaraki and colleagues (2019, 2020) support this view, and show a potentially mediating role of sleep debt in the link between shift and night work and MSD risk. Eliminating overnight work in a manufacturing context indeed significantly reduced MSD symptoms (Lee et al. 2020), suggesting a role of night shifts in the etiology of MSD.

Additionally, as shown in the study by Zhao et al. (2012), high BMI in combination with shift work led to high MSD risk. We therefore propose a modified pathway that specifies the association of Figure 1 in more detail regarding sleep, food intake, and BMI based on other findings (see Figure 2): Long work hours, night and shift work are assumed to lead to poor and short sleep, which in turn increases the likelihood for high calory intake (Capers et al. 2015; Dashti et al. 2015; Shechter, Grandner and St-Onge 2014; Zuraikat et al. 2020). Pilot data indicate that sleep extension in individuals sleeping less than 6h per day might indeed lead to better diet quality and lower caloric intake (Al Khatib et al. 2018). The picture is likely more complex, though, as timing of food intake, and duration of eating periods per 24h might be of great importance (Garaulet/Gómez-Abellán 2014; Wang et al. 2014), especially in the shift work context. Indeed, a systematic review and meta-analysis of more than 15,000 individuals did not show differences in energy intake between day and shift workers (Bonham, Bonnell and Huggins 2016). Such between-subject comparisons however are limited, as they cannot control for inter-individual differences that might be important confounders, such as chronotype, food availability, or socio-economic status (Dashti et al. 2019). An alternative or additional consideration that will need to be disentangled from association between work hours, sleep, and body composition, is that BMI might serve as a proxy for comorbidity. Indeed, Zhao et al. (2012) did not dispose of overall health measures or indices such as the Charlson Comorbidity Index (CCI, Charlson et al. 1987), so that the overall health of study participants might have been, at least in part, reflected by the BMI measure.

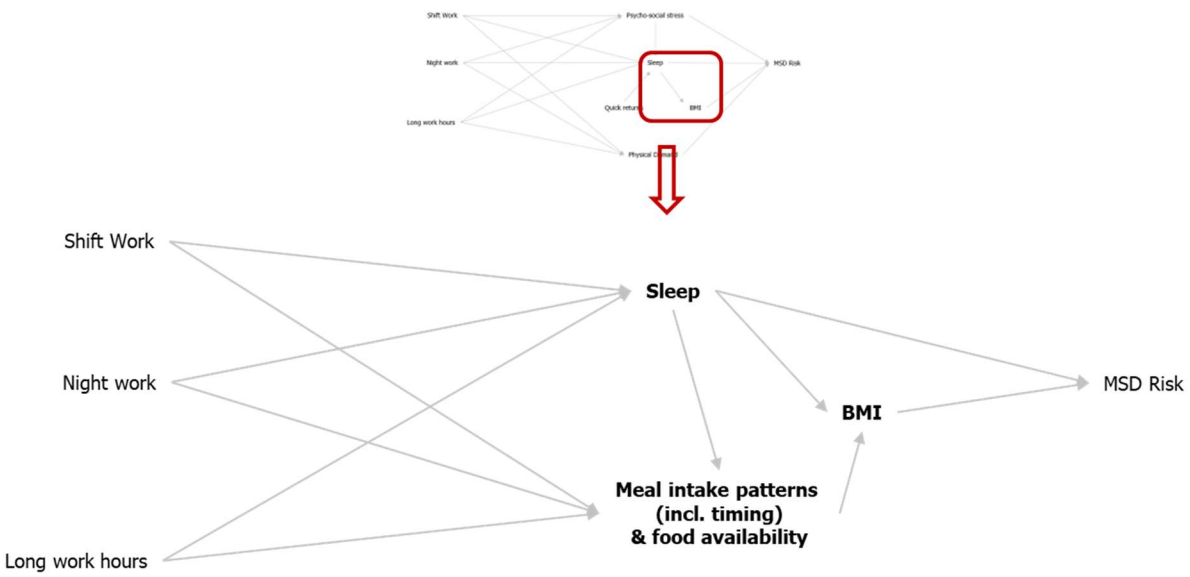

Figure 2. Zooming in onto the theoretical associations between work hours, sleep, food intake, BMI and MSD risk as they emerge from the literature and first findings outside of the occupational health and musculoskeletal disease field. The risk factors and their respective links in the associations between work hours and MSD risk in bold are currently inferred, and not empirically demonstrated.

Strengths and limitations

This review study has the strength of combining evidence from multiple studies in the healthcare sector, updating the evidence on the prior review by Caruso/Waters (2008) especially regarding associations with long work hours, shift work, and MSD. Limitations, however, include the remaining scarcity of high-quality studies on long daily work hours and night shifts with a valid exposure assessment of actual work hours and objective outcomes. While many studies have included physical demands as control or mediator variable, the interplay between work hours, demands, sleep and individual risk factors should be investigated further. Additionally, studies reporting specific musculoskeletal symptoms might have not been identified with our search string, which was not targeted to outcomes such as back pain.

Practical implications

The findings of this study can be used for workplace interventions, in which shift schedules are re-designed to mitigate negative effects of work scheduling on MSD risk. Since evidence was strongest for long work hours, a limitation in weekly or daily work hours seems the potentially most beneficial intervention. Whether these limits should be implemented, beyond current occupational standards, is currently unclear, but might be informed by future analyses of physical demand and workload in the context of work hours. For example, while it is currently unclear whether long shifts independently increase MSD risk, it has been shown that performance measures in nurses significantly drop after working 12h shifts, and muscle fatigue increases, independently of the timing of shift (Thompson 2019; Thompson, Stock and Banuelas 2017). Taken together with these cross-sectional studies, these physiological findings

from more controlled laboratory studies indicate a benefit when limiting physical demands and/or daily work hours.

Implications for future research

The current lack of research with regards to the effects of shifts, work at short notice, and specific shift schedule characteristics such as quick returns, shift rotation speed and direction on health, and more specifically on MSD risk in nursing populations is clear from our analyses. All work characteristic investigations should not only include detailed, time-of-day workload information, but would also benefit from the assessment of potential behavioral mediators in the link between work hours and MSD risk, such as sleep, food intake, and other lifestyle factors. A better understanding of direct and indirect, mediated effects of work hours on MSD risk will allow to identify the most promising intervention targets.

While long weekly work hours were investigated in several studies, daily work hours were usually not reported or queried in the studies at hand. This type of information would also be important since studies on injury risk show that the same amount of weekly work hours could lead to very different risk estimates depending on the schedule, and more specifically depending on daily work hours. For example, injury risk in a 6-day 8h/day schedule was estimated to be comparable to a standard 40h week, but estimated injury risk increased by about 20% when distributing the 48h weekly work hours onto 4x12h day shifts, and by about 55% for 4x12h night shifts (Folkard/Lombardi 2006). Future research with a more fine-grained exposure assessment, such as including information on daily and weekly work hours, is therefore necessary to disentangle risk factors related to work duration.

In our proposed pathway model in Figure 2, we hypothesize a link between work hours, sleep, caloric intake, and BMI. Future work tracking food choices, intake (incl., timing), and availability within the same individuals working distinct shifts will be necessary to dissect the role of work timing on energy intake, and thus downstream effects on weight regulation and BMI.

Finally, prospective cohort and intervention studies should be conducted, where objective measures of work organization, demands, and individual factors such as sleep, or stress should be part of the data collection. Diary or experience sampling measures could help quantify demands and lead to new insight into MSD risks in subgroups.

Conclusions

This updated review shows associations between long weekly work hours and shift work with increased MSD risks in the healthcare sector. Additionally, high demands, impaired sleep, and individual factors such as high BMI are associated with the work schedule and further increase MSD risk. Prevention of work-related MSDs seems most important since MSD prevalence is on a high level in the nursing profession, and demographic development in many countries leads to an increased demand in nurses and healthcare professionals in the future. Prevention measures should target both reduction of physical and psychosocial demands, as well as improvement of the work schedule. A reduction of working hours, night work, or shift work

could reduce MSD risks and improve sleep and recovery between shifts. Additionally, individual factors should be targeted, to improve sleep hygiene, diet, and reduce high BMI.

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