

A Review of Work Schedule Issues and Musculoskeletal Disorders with an Emphasis on the Healthcare Sector

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Abstract: Musculoskeletal disorders (MSDs) are a significant cause of morbidity in healthcare workers. The influence of shift work and long work hours on risk for MSDs is an area that needs further exploration. The purpose of this report is to assess research progress and gaps across studies that examined the relationship between demanding work schedules and MSD outcomes. A literature search identified 23 peer-reviewed publications in the English language that examined MSDs and long work hours, shift work, extended work shifts, mandatory overtime, or weekend work. Eight studies that examined long work hours and had some controls for physical job demands reported a significant increase in one or more measures of MSDs. Fourteen studies examining shift work had incomparable methods and types of shift work, and therefore, no clear trends in findings were identified. A small number of studies examined mandatory overtime, work on weekends and days off, and less than 10 h off between shifts. Given the complexity of the work schedule research topic, relatively few studies have adequately examined the relationship of work schedules and musculoskeletal outcomes. The review discusses research gaps including methodological issues and suggests research priorities.

Key words: Review, Working hours, Shift work, Long work hours, Work schedule tolerance, Extended work periods, Musculoskeletal disorders

Introduction

Work hours in healthcare often involve extended work shifts (longer than 8 h per day), long work hours (greater than 40 h per week), on-call work, mandatory overtime, and shift work (work times other than 7:00 A.M. to 6:00 P.M.) to deliver care around the clock. The shortage of nurses and other types of healthcare workers push those available to work longer hours to fill the vacancies. Studies of many types of workers report these demanding work schedules are associated with several health and safety risks including psychological, gastrointestinal, and

cardiovascular disturbances, injuries and automobile crashes, cancer, and adverse reproductive outcomes^{1–12}). In addition, workers may be more prone to poor health behaviors such as smoking, drug and alcohol abuse and less physical activity. Musculoskeletal disorders (MSDs) are a significant cause of morbidity in healthcare workers, and research on the effects of demanding work schedules on MSD risk is an area that needs further exploration. The purpose of this report is to assess research progress to date examining the relationship between demanding work schedules and MSD outcomes and to identify areas for future study.

Theoretical Framework and Possible Mechanisms Linking Demanding Work Schedules and MSDs

The National Academy of Sciences' National Research Council and Institute of Medicine (NRC/IOM) proposed

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a theoretical model for development of work-related MSDs¹³). The model proposed by the NRC/IOM, which is shown in Fig. 1, indicates that most risk factors act through a biomechanical loading pathway to cause work-related MSD health outcomes. The NRC/IOM report rec-

ognized the potential role of work organization and psychosocial variables, but they did not make any determination regarding the relative impact of the interaction between the various types of stressors. Granata and Marras¹⁴) showed that coactivity of the agonist and antagonist muscles in the trunk often occurs during lifting and moving of objects in order to stabilize the spine, and that this coactivity tends to increase the loads on the spine above what they would be if the coactivity was negligible. This means that for any specific back loading task, such as lifting a patient, any stressor that tends to increase the coactivity likely will increase the spinal loads above what they would have been if the stressor was absent. This is important for workers with demanding work schedules, because researchers have shown that factors such as psychosocial stressors, a mismatch between the personality traits of the worker and the work characteristics, stress, and fatigue can significantly increase the amount of coactivity occurring during manual material handling tasks, resulting in significantly higher spine loading compared with similar external physical loading under optimal conditions¹⁵⁻¹⁷). Therefore, it is possible that work schedule factors, such as shift work, overtime, and mandatory overtime could also create increased coactivity and result in higher than expected muscle loading on the spine, shoulders, and other joints.

Figure 2 displays a theoretical framework for studying effects of demanding work schedules on musculoskeletal outcomes. The framework evolved from models by Barton *et al.*¹⁸), Sauter *et al.*¹⁹), and Caruso *et al.*²⁰). The framework theorizes that demanding work schedules increase risk for adverse outcomes through several pathways: less time to sleep and recover from work, longer exposure to workplace hazards and demands, and less time to attend to family and other non-work responsibilities. Physical demands interact with work schedules to

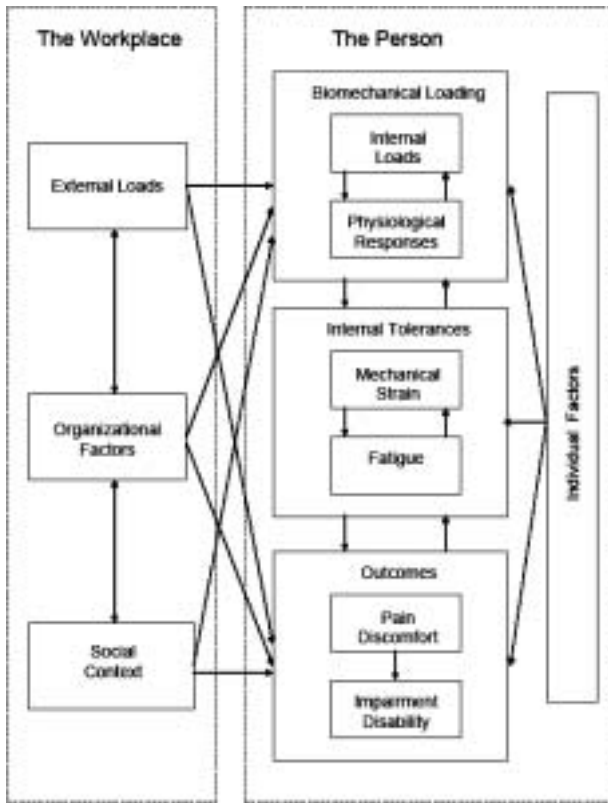


Fig. 1. Theoretical framework for factors associated with development of musculoskeletal disorders from National Research Council and Institute of Medicine (2001) *Musculoskeletal Disorders and the Workplace: Low Back and Upper Extremities*. National Academy Press.

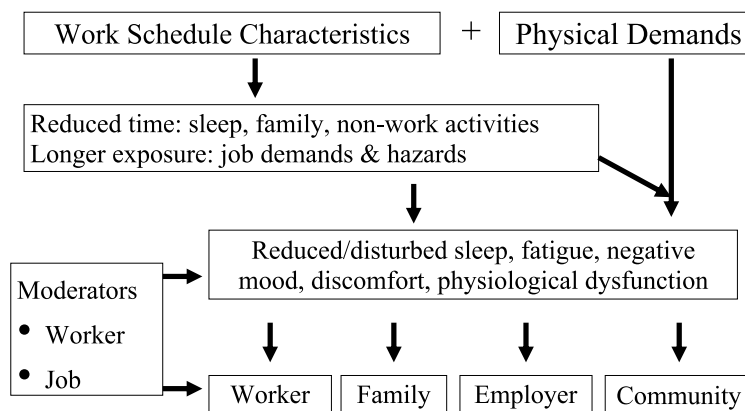


Fig. 2. Framework for study of negative impacts of demanding work schedules (adapted from Caruso *et al.*, 2006).

influence outcomes. These, in turn, increase risks for sleep disturbances, fatigue, stress, negative mood, discomfort, pain and decrements in functioning. Sleep disturbances may interfere with important body defenses and may shift the immune system T helper cell balance toward inflammation²¹). All of these could contribute to increases in MSDs. In addition, workers may have less time for exercise, and to prepare and consume a nutritious diet^{22–24}). High stress may increase negative health behaviors such as tobacco and alcohol use^{24, 25}). These effects, in turn, can increase risks for illnesses and injuries to the worker. In addition, negative effects of demanding work schedules to workers could have broad-reaching effects: 1) decreased ability of the ill or injured worker to provide for family or participate in matters outside of work; 2) negative impacts on the employer through reduced productivity and quality of services and products, as well as higher healthcare and personnel costs; and 3) negative impacts to the community through medical errors, higher costs of supporting the ill and disabled, reduction in workforce due to early disability, and workers with needed skills avoiding jobs such as nursing, leading to a nursing shortage^{26–31}). Whether demanding work schedules lead to these negative outcomes may depend on several moderating factors including characteristics of the worker and the job^{18, 20, 32}). Worker characteristics that may influence this relationship include age, gender, capabilities, resources (financial, support from family and friends), health behaviors, home environment, and non-work responsibilities. Characteristics of the job include physical, mental, and emotional demands, exposures to other occupational hazards (chemicals, gases, infectious organisms, noise, etc.), rewards, support from coworkers and management, control over work, and organizational context^{33–35}).

Work Schedule Details to Consider

Work schedules vary by many factors. Caruso *et al.*²⁰) list 25 different characteristics of work schedules to consider assessing in studies including time of day, fixed times or rotating shifts, rotation speed and direction of shift changes, length of shift, hours worked per week and longer periods (e.g., a year), distribution of work time (e.g., number of consecutive work days, split shifts, length of time off between shifts), predictability of schedule, frequency of schedule change, worker control over the schedule, mandatory overtime, on-call work, commute time, electronic connection to work during off time, and compatibility of schedule with non-work activities. Shift rotations can be forward (from day shift to evening shift to night shift) or backward (from evening to day to night shift). Studies indicate backward rotations are associated with more adverse outcomes including subjective sleep

and health complaints, objective measures of blood pressure and blood glucose, as well as personnel turnover and worker productivity^{36–39}). This may be due to reduced time off between shifts and the need for earlier wake up times with each shift change. Fast rotations change shifts every few days, weekly rotations change shifts once a week, and slow rotations change shifts every two weeks or more. Another consideration are schedules that combine multiple demanding work scheduling features, such as shift work and extended shifts (e.g., 12-h night shifts).

Materials and Methods

A review was conducted of 23 studies that examined relationships between work schedules and musculoskeletal outcomes. The studies were identified from a search of the authors' personal collection of research articles and a search of OVID. 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\$. The reference lists of relevant papers were examined for potential studies for the review.

Three criteria were used to select the 23 studies: (1) published in the English language; (2) peer-reviewed publication; (3) examined relationship of work schedules and musculoskeletal outcomes; and (4) published from 1980 (the earliest date a paper on this topic was published) to January 2008. Work schedule characteristics targeted for the review were shift work, long work hours, extended work shifts, mandatory overtime, weekend work, and less than 10 h off between shifts. The within-shift rest break literature was not included in this review. Thirteen of the studies reviewed (57%) examined healthcare workers: non-specified healthcare workers, nurses, nurses' aides, physicians, and dental hygienists. The remainder of the studies examined factory workers, film technicians, off shore oil workers, office workers, police officers, transit vehicle operators, and samples of diverse types of workers.

Results

Shift Work

Table 1 displays a summary of 14 studies that examined associations between types of shift work schedules and work-related MSD outcomes. Measures of shift work varied across studies from a dichotomous variable, shift work present or not, to more specific shift work schedules. Four studies that controlled for physical job demands reported no significant difference in MSD risk between non-specified shift work schedules and day shift^{33, 40–42}). Of five studies comparing six different

Table 1. Studies examining shift work and MSDs

Reference Information			Results by Type of MSD Examined							
			Non-Specific MSD or > One MSD		Back		Neck		Shoulder	Arm/Hand
Risk 1st shift listed vs. 2nd shift listed	First Author	Type of Worker Controls	Symptoms	Leave, Incident Report or Claims	Symptoms	Diagnoses or Claims	Symptoms	Diagnoses	Symptoms	Symptoms
Non-specific shift work vs. days	Fredricksson <i>et al.</i> ³³⁾	diverse physical &						+ age NS physical		
	Morikawa <i>et al.</i> ⁴⁰⁾	male factory physical		NS						
	Solomon <i>et al.</i> ⁴¹⁾	men diverse physical &		NS						
	Thorbjörnsson <i>et al.</i> ⁴²⁾	diverse physical &				NS				
	Grooten <i>et al.</i> ⁷³⁾	diverse age &		Men + Women NS						
	Lipscomb <i>et al.</i> ⁶⁰⁾	nurses age			+		NS		+	
	Trinkoff <i>et al.</i> ⁵⁸⁾	nurses age				NS	NS		NS	
Fixed vs. rota	Waters <i>et al.</i> ⁵⁹⁾	diverse none			NS					NS
	Engkvist <i>et al.</i> ⁵⁵⁾	women diverse physical &				NS				
Day vs. evening or nights	Myers <i>et al.</i> ⁴³⁾	nurse's aide none		+						
Fast 12 h rota vs. days	Angersbach <i>et al.</i> ⁴⁴⁾	male factory none		+						
12 h day/night rota vs. days	Parkes ⁴⁷⁾	male off shore oil physical	NS							
Irregular with nights vs. days	Ottmann <i>et al.</i> ⁴⁵⁾	policemen none	+							
Day/evening rota vs. days	Sveinsdottir ⁴⁶⁾	female nurses none	+							
3 shift rota vs. days	Sveinsdottir ⁴⁶⁾		NS							

Note: "Rota"=rotation; "physical" indicates physical demands; "&" indicates controlled for additional factors; NS=not significant.

types of shift rotations to day shifts, Myers *et al.*⁴³⁾ reported higher MSD risk on day shift, Angersbach *et al.*⁴⁴⁾ and Ottmann *et al.*⁴⁵⁾ reported more risk on the rotating shifts, Sveinsdottir⁴⁶⁾ reported mixed results, and Parkes⁴⁷⁾ reported no significant difference. Myers *et al.*⁴³⁾ did not control for physical job demands, but commented that the nurses' aides on day shift had the most physical demands, which might have influenced their study findings. Angersbach *et al.*⁴⁴⁾ noted that the work of day shift required more physical demands than the rotating shift, yet the shift workers had more injuries. Their analyses did not control for other influential factors. Parkes⁴⁷⁾, who found no difference, studied the same type of workers (offshore oil) on day and rotating shifts and controlled for physical demands. In summary, studies of associations between shift work and MSDs reported mixed results.

The types of shift work patterns examined were limited and investigators did not always control for potential confounding factors.

Long Work Hours and Other Schedule Characteristics

Table 2 displays information about studies examining long work hours and other schedule characteristics.

Long Work Hours

Fifteen studies examined associations between long work hours and MSDs. Measures of long work hours across studies varied from questions detailing hours per week, to one general question asking whether the participant worked too much overtime.

Non-specific Musculoskeletal Outcomes. Six studies examined associations between long work hours and non-

Table 2. Descriptive information about the studies examining long work hours and MSDs

Author	Sample	Work schedule measure	Controlled physical demands or other factors
Allen <i>et al.</i> ⁵⁰⁾	manufacturing workers	h/wk voluntary overtime	other factors
Bergqvist <i>et al.</i> ⁵⁷⁾	office workers	frequent overtime, overtime on short notice	physical demands and other factors
Bourdouxhe and Toulouse ⁵²⁾	film technicians	h/shift, wk/month, wk/yr	none
Engkvist <i>et al.</i> ⁵⁵⁾	female nurses	1 week prior to injury: work hrs, overtime, fixed or rolling schedule	physical demands and other factors
Fredriksson <i>et al.</i> ³³⁾	broad range of occupations	<ul style="list-style-type: none"> • Overtime yes/no • Day versus shift work • Interactions: overtime and domestic workload 	physical demands
Josephson <i>et al.</i> ⁴⁸⁾	female workers	total work hrs per week = paid work and unpaid work (domestic childcare work but not weekend work)	physical demands and other factors
Krause <i>et al.</i> ⁵⁶⁾	transit vehicle operators	weekly driving hrs during last 12 months: 20–30 h, 31–50 h, >50 h	physical demands and other factors
Lipscomb <i>et al.</i> ⁶⁰⁾	nurses	h/day: ≤8; 9–11; ≥12 h/wk: ≤40; 41–49; ≥50 day versus other shift Interactions: h/day × h/week	age
O'Brien-Pallas <i>et al.</i> ⁴⁹⁾	nurses linked to hospitals	work >1 h overtime/wk	physical demands and other factors
Ono <i>et al.</i> ⁵³⁾	nursery school teachers	Overwork ≥4 h/wk	physical demands and other factors
Smith <i>et al.</i> ⁵¹⁾	physicians	“too much overtime”	other factors
Takigawa <i>et al.</i> ⁵⁴⁾	healthcare workers	h/wk: <41, 41–50, >50	other factors
Thorbjörnsson <i>et al.</i> ⁴²⁾	Swedish population	overtime, shift work yes/no	physical demands and other factors
Trinkoff <i>et al.</i> ⁵⁸⁾	nurses	h/day, h/wk, weekend/month, day vs. other shift, # shifts ≥13 h, <10 h off between shifts, work while sick, work on day off, mandatory overtime, on-call work	physical demands and other factors
Waters <i>et al.</i> ⁵⁹⁾	representative sample of US workers	h/wk, shift work (yes or no), mandatory overtime	none

specific MSD outcomes. A study by Josephson *et al.*⁴⁸⁾ of female workers and a study by O'Brien-Pallas *et al.*⁴⁹⁾ of nurses, both controlling for physical demands, reported long work hours were associated with increased healthcare provider visits or short-term disability claims. O'Brien-Pallas *et al.*⁴⁹⁾ estimated that a hospital's probability of having a high nurse lost-time claim rate increased by 70% with each 25% increase in the percentage of their nurses reporting more than 1 h of overtime per week. Allen *et al.*⁵⁰⁾ reported no relationship between voluntary overtime ranging up to 60+ h per week and MS injuries in workers at a truck manufacturing plant. One⁵¹⁾ of the four studies examining symptoms reported a significant increase, while the other three were not significant^{52–54)}. Bourdouxhe and Toulouse⁵²⁾ theorized their findings might have been influenced by lack of a comparison group working 40 h per week, since almost all of their film technicians worked very long hours. In this study, the two types of technicians with the longest hours showed the most MSDs.

Back. Seven studies examined back outcomes. Of studies that controlled for physical demands, the Engkvist *et al.*⁵⁵⁾ study of nurses and the Krause *et al.*⁵⁶⁾ study of transit operators reported long work hours were associated with increases in claims. Krause *et al.*'s⁵⁶⁾ prospective 7.5-yr study estimated that severe low back injury workers' compensation claims increased by 39% for every 10-h increase in driving time for transit operators, and estimated that a reduction of work hours below 30 h per week would result in a 59% reduction in severe low back injury workers' compensation claims. Other studies with controls for physical demands reported no significant relationships: the Josephson *et al.*⁴⁸⁾ study of female workers reported no relationship with healthcare provider visits, and the Bergqvist *et al.*⁵⁷⁾ study of office workers reported no relationship with back pain. The Trinkoff *et al.*⁵⁸⁾ longitudinal study of nurses reported a work day factor indicating long work hours (consisting of several survey items) was associated with increased risk for back symptoms when controlling for age. When physical demands

were added to the statistical model, long work hours were not significant, which the authors suggested indicated the effects of work hours are explained by physical demands: nurses working longer hours will be exposed to longer periods of physical demands, which in turn increases risk for back symptoms. Of two studies with no controls for physical demands, Smith *et al.*⁵¹⁾ reported increases in back pain in physicians working long hours, whereas Waters *et al.*⁵⁹⁾ reported the opposite relationship: long work hours were associated with less back pain in a sample of the general U.S. working population.

Neck. Three studies with controls for physical demands examined neck outcomes. Fredricksson *et al.*³³⁾ reported increases in diagnoses of the neck in a diverse sample of workers, whereas the Bergqvist *et al.*⁵⁷⁾ study of office workers showed no significant relationship with neck discomfort. Trinkoff *et al.*⁵⁸⁾ reported a work day factor indicating long work hours was significantly associated with an increase in neck symptoms while controlling for age. Similar to their finding for back symptoms, when physical demands were added to the statistical model, long work hours were not significant, which the authors said indicated the effects appeared to be explained by physical demands.

Shoulder. Four studies examined shoulder outcomes. Of studies that controlled for physical demands, Fredricksson *et al.*³³⁾ reported increases in diagnoses of the shoulder, whereas Bergqvist *et al.*⁵⁷⁾ showed no significant relationship with discomfort. Similar to their findings with neck and back symptoms, Trinkoff *et al.*⁵⁸⁾ reported a work day factor indicating long work hours were associated with shoulder symptoms while controlling for age. When physical demands were added to the statistical model, long work hours were not significant, which the authors said indicated the effects were explained by physical demands. Smith *et al.*⁵¹⁾, a study with no controls, reported increases in shoulder pain in physicians working long hours.

Arm/Hand. Three studies examined arm or hand outcomes. The two studies with controls for physical demands by Bergqvist *et al.*⁵⁷⁾ and Ono *et al.*⁵³⁾ (teachers) reported increases in discomfort, while Waters *et al.*⁵⁹⁾ with no controls reported long work hours were associated with less arm/hand pain.

1) Mandatory Overtime

Two studies examined mandatory overtime. Trinkoff *et al.*⁵⁸⁾ reported mandatory overtime was associated with increased risk for pain of the back, neck and shoulder when controlling for age. Their constructed factor consisting of items which indicated mandatory overtime or required on-call work was associated with increased risk for shoulder symptoms while controlling for age. When

physical demands were added to the statistical model, long work hours were not significant, which the authors suggested indicated that the effects of long work hours appear to be explained by physical demands. The mandatory overtime factor alone showed no significant relationship with neck or back symptoms. Waters *et al.*⁵⁹⁾, which had no controls for other factors, reported mandatory overtime was associated with an increased risk for pain of the back, hand, and arm.

2) Extended Work Shifts

Two studies examined shifts longer than 8 h. Lipscomb *et al.*⁶⁰⁾, who conducted a cross-sectional study of nurses with controls for age, reported increased back symptoms with shifts ≥ 12 h, but no increase in neck or shoulder symptoms. Trinkoff *et al.*⁵⁸⁾ reported nurses with shifts longer than 13 h reported increased symptoms of the neck, shoulder, and back while controlling for age.

Combinations of Demanding Characteristics

Two studies examined work schedules that have more than one difficult scheduling characteristic. Women working a combination of shift work and long hours had significantly higher reports of lower back pain during medical interviews in a study by Thorbjörnsson *et al.*⁴²⁾ which controlled for physical demands. The combination of extended shifts and working more than 40 h per week was associated with increases in self-reported symptoms of the neck, back, and shoulder in a study of nurses by Lipscomb *et al.*⁶⁰⁾ which controlled for age.

Two studies examined associations with domestic workload. Fredriksson *et al.*³³⁾ reported higher domestic workloads combined with long work hours were associated with increased reports of medical treatment for neck disorders in women and men. Josephson *et al.*⁴⁸⁾ reported higher domestic workload and longer paid work separately increased care-seeking for neck or shoulder pain, but the combination of longer paid hours and domestic workload were not significant, which the authors theorized might be due to a lack of people working very long combined hours.

A study by Waters *et al.*⁵⁹⁾ of a representative sample of U.S. workers found that self-reported back and hand/wrist disorders doubled when workers reported exposure to both high physical workload and high levels of work stress. Although Waters *et al.*⁵⁹⁾ did not find a significant relationship between work hours and reports of low back pain in the study, it is possible long work hours and demanding shift-work schedules lead to higher work stress. This finding may indicate potentially higher risks when the job design combines demanding schedules and high physical demands.

Other Work Schedule Characteristics

Trinkoff *et al.*⁵⁸⁾ examined several related work scheduling patterns in nurses. The study reported less than 10 h off between shifts increased symptoms of the neck, shoulder and back while controlling for age. This study also reported that nurses with sequences of greater than 6 consecutive work days reported increased symptoms of the shoulder, but not of the neck or back. Working on a day off increased symptoms of the shoulder, neck, and back. Working on weekends increased symptoms of the back (while controlling for age), but not the shoulder or neck. Lipscomb *et al.*⁶⁰⁾ also examined weekend work (while controlling for age) and found that back symptoms were significant, whereas neck and shoulder symptoms were not.

Discussion

Research attention to this topic has increased recently: 18 of the 23 studies in the review were published since 2000. However, only a small number of work schedule patterns have been studied to date, and for most of the scheduling patterns, findings are available from only one study. Therefore, much remains to be examined about the relationship of work schedules and musculoskeletal outcomes.

Eight studies that had some controls for physical demands reported long work hours were associated with a significant increase in one or more measures of MSDs. Trinkoff *et al.*⁵⁸⁾ reported the relationship appeared to be explained by physical demands: longer hours may increase the amount of physical activities, which in turn may increase risk. Too few studies and incomparable methods across shift work studies make it difficult to make summary statements across findings.

Methodological Issues

Insights about methodological issues for studies of work schedules are discussed by Knutsson⁶¹⁾. These include adequate comparison groups, need for complete descriptions of the workers, the job, and the work schedule, types of outcomes measures, and accounting for other influential factors.

An adequate comparison group to compare with workers on shift work or long work hours is often missing from previous studies of work schedules. An adequate comparison group would include workers in jobs with similar occupational exposures and physical demands as the exposed group. This is often difficult to achieve because the nature of the physical demands may differ significantly between day work and non-day shifts due to the nature of work that needs to be done at different times of the day. For example, Goncalves *et al.*⁶²⁾ observed

that nurses on day shift were more physically active on the job, spending 13% of the time sitting as compared with 46% of the time sitting during night shift. Other work-related factors that may differ as a function of time of day include supervisor-to-employee ratio, pressures to perform, number of coworkers and other people at the worksite, activities at the worksite, types of food available, and work environment (lighting, noise, environmental temperature and humidity, and chemical exposure). These other factors may influence health and safety outcomes. Also, the best comparison group would have no previous history of shift work or long work hours, because this history may be associated with continued adverse effects on health even after moving to a regular daytime schedule^{44, 63–66)}. Some studies did not have participants working very long hours or a regular full-time schedule for comparison, which may account for null findings. While it is often difficult to include adequate control groups, ideally these factors would be assessed and accounted for in future studies and considered when evaluating study findings.

Self-selection of work schedule and job will influence findings and may result in a survivor effect. That is, people who feel they could not tolerate a non-standard work schedule would tend to avoid jobs requiring shift work or long work hours, leaving workers who are more likely to tolerate these scheduling demands. As a result, any significant finding is particularly noteworthy.

Seniority and age also impact shift and job assignment. As workers' seniority and job-bidding influence increase, they tend to move to day shift, so day shift is associated with increased years of employment and increased age⁶⁷⁾. As a result, effect estimates will be attenuated when comparing health in younger shift workers (who tend to be healthier), with older day workers (who tend to have more health problems). This will reduce the likelihood of finding differences in health across shifts.

Other factors have been reported to influence the relationship of work schedules and other types of health outcomes. These include gender, compensation (as pay increased, negative outcome decreased), macro-economic conditions (recession or depression), commute time, and occupational exposures (chemicals, extremes of temperature, noise)^{3, 20)}. Ideally, studies will account for these other factors.

Clear and complete description of the work schedule and job demands is critical when comparing findings across studies, but previous research often lacks this information. Caruso *et al.*²⁰⁾ list 25 different characteristics of work schedules to consider when assessing studies. For example, risks for accidents and incidents tend to be the lowest for day shift, followed by evening shift, with night shift showing the highest risks⁴⁾. Early start times of 6

AM or earlier truncate sleep and are associated with more fatigue and sleepiness⁶⁸). Backward rotations show higher risk than forward rotations^{36–39}). Fast rotations that have more than one shift change per week in a forward direction (e.g., day, day, evening, evening, night, off, off) are recommended over backward weekly shift rotations⁶⁹). Long sequences of work days without a day off increase risk. All of these details about work scheduling are critical for research to establish associations with health and to identify the key work schedule characteristics influencing risk and requiring modification.

A wide range of health outcomes for MSDs have been used in studies. These health outcomes have included simple symptom surveys asking questions about pain in various body parts, determinations of whether or not the individual had sought medical care, absenteeism, workers' compensation claims, and other less defined outcomes (diffuse reports of musculoskeletal pain). The most widely used method for assessing work-related MSD health effects among the reviewed studies was the NORDIC Questionnaire, a standardized series of questions about musculoskeletal complaints⁷⁰). One problem across study measures of MSDs is the wide range of severity seen, ranging from early signs of discomfort related to the beginnings of musculoskeletal damage, to permanent disability due to severe damage. For example, as the level of severity of back pain increases, workers tend to show increases in lost work time, impairment, job reassignment, and ultimately compensable disability⁷¹). Optimally, in order to compare the impact of work schedule variables on risk of work-related MSDs, the study outcome measure should reflect both the duration and magnitude of the health outcome of interest. Use of standardized health indicators will improve the ability of researchers to examine the complex interactions between these work schedule variables and other known work-related MSD risk factors across multiple studies.

Physical factors such as heavy lifting, pushing and pulling, awkward postures, or repeated forceful exertions play a major role in development of work-related MSDs^{13, 72}). Therefore, it is critical to account for these factors when examining the relationship between work schedule variables and work-related MSDs. Ways of measuring physical demands varied widely across studies. For example, a simple method is shown in Fig. 3, which is a one-item survey asking about physical exertion. A minimal level of information would be obtained

Rate the overall physical effort demanded by your job over that past 3 months.

Extremely | _____ | Extremely
Light Heavy

Fig. 3. One survey item for rating physical demands.

from this type of measure. Another rough estimate for physical demands used by some studies has been job category⁵⁶). Analyses of existing data sets, such as the General Social Survey, often only have the imprecise measures of physical job demands, making it difficult to control for varying levels and types of physical demands that likely occur across participants in these types of studies.

In comparison, a more detailed method for assessing physical demands is shown in Fig. 4 (developed for a study in progress), which asks frequency and types of pulling, pushing, or lifting activities, and use of assistive devices to carry out these tasks. This more detailed method will likely give a better estimate and control for the influence of physical demands on the relationship between work schedules and MSD outcomes. For example, do 12-h shifts with 4 lifts per hour show a higher risk than 8-h shifts with 4 lifts per hour? In this case, the amount of physical demands per hour is comparable, but workers on 12-h shifts are carrying out these tasks an additional 4 h before having an extended break to sleep and rest. Longer periods of physical demands may increase risks as compared with shorter work periods. For the most part, existing studies have not adequately measured and controlled for physical exposures in the analyses or by research design to provide evidence to answer this important type of question. In a recent report, Waters *et al.*⁵⁹) suggested that it was important to “actually quantify the exposures to physical risk factors, rather than rely on self-reported measures.” This is because many studies of musculoskeletal disorders failed to objectively measure exposure, making it difficult to examine relationships between exposure to risk factors and development of health outcomes. Future studies should include better assessment of job demands to permit simultaneous examination of the relationship and interaction between work schedule and job demands, to improve our understanding of the contribution of these factors in development of work-related MSDs.

Suggested Research Priorities

In 2006, the National Occupational Research Agenda (NORA) Long Work Hours Team published research priorities for occupational health and safety risks associated with long work hours²⁰). The NORA Long Work Hours Team was a group of experts from industry, labor, and the U.S. government who were recruited by NIOSH to identify critical issues connected with long work hours and to suggest priorities for future research. The research priorities published by the NORA Long Work Hours Team are relevant for work hours and MSDs and the following priorities are adapted from their work.

Task	Indicate the average number of times you performed each task per week during last 3 months. If not performed enter "0".	What assistive devices do you frequently use for these activities? Fill in all circles that apply.								Did this task ever directly result in an injury, pain, or limited mobility that caused you to take time off from work?	
		Draw Sheet	Friction Reducing Device	Gait (walking) Belt	Trapeze	Hoyer-Like Floor Lift	Ceiling Lift	Several Staff Help	Convertible Chair Bed		Hospital Lift Team
Reposition patient in bed		0	0	0	0	0	0	0	0	0	Yes No
Partial patient transfer between bed & chair or commode (patient assisted somewhat)		0	0	0	0	0	0	0	0	0	Yes No
Full patient transfer between bed and chair or commode (patient not assisting)		0	0	0		0	0	0		0	Yes No
Full patient transfer between bed and stretcher (patient not assisting)		0	0	0		0	0	0		0	Yes No
Lift patient off floor		0	0	0	0	0	0	0	0	0	Yes No
Push or pull bed or other heavy object								0			Yes No

Fig. 4. Several survey items for rating of physical demands.
Instructions: The chart lists various tasks performed at work. For each task that you performed, please fill in the information. If you did not perform the task, leave the row blank.

- Research needs to provide a clear and complete description of the work schedules, the workers, and the work environment to better compare findings across studies, build evidence, and move the science forward.
- Demanding work schedules, such as those requiring mandatory overtime, shift work, or combinations of demanding work schedule features should receive priority.
- Research needs to measure and control for factors that influence the relationship between work hours and MSD outcomes. Assessment and accounting of physical demands is a priority.
- Further development of objective methods for measuring physical demands and work schedules would be helpful.
- Research should explore a wider range of possible outcomes:
 - a variety of symptoms and functional deficits associated with having less time for sleep, work recovery, and other life necessities, as well as longer exposures to occupational hazards and demands;
 - chronic diseases, as well as acute injuries and illnesses;
 - risks for the employer such as reduced productivity and quality of goods and services, increased absenteeism, higher healthcare and workers' compensation costs, and less successful recruitment and retention;
 - longer term impacts of shift work and long work hour-related worker fatigue, illnesses, and injuries on the family and community.
- Research should examine workers in vulnerable groups such as women who are pregnant, older workers, workers with chronic illnesses, workers exposed to more demanding occupational hazards, and socio-economically disadvantaged workers.
- Research should develop and test interventions to reduce risks, such as workplace interventions to improve work scheduling patterns, related organization of work factors, and worker health behaviors, as well as studies of the impact of broader public policy measures (e.g., impact of the state laws limiting mandatory overtime for nurses).

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