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Influence of fatigue on construction workers' physical and cognitive function

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Background	Despite scientific evidence linking workers' fatigue to occupational safety (due to impaired physical or cognitive function), little is known about this relationship in construction workers.
Aims	To assess the association between construction workers' reported fatigue and their perceived difficulties with physical and cognitive functions.
Methods	Using data from a convenience sample of US construction workers participating in the 2010–11 National Health Interview Survey two multivariate weighted logistic regression models were built to predict difficulty with physical and with cognitive functions associated with workers' reported fatigue, while controlling for age, smoking status, alcohol consumption status, sleep hygiene, psychological distress and arthritis status.
Results	Of 606 construction workers surveyed, 49% reported being 'tired some days' in the past 3 months and 10% reported 'tired most days or every day'. Compared with those feeling 'never tired', workers who felt 'tired some days' were significantly more likely to report difficulty with physical function (adjusted odds ratio [AOR] = 2.03; 95% confidence interval [CI] 1.17–3.51) and cognitive function (AOR = 2.27; 95% CI 1.06–4.88) after controlling for potential confounders.
Conclusions	Our results suggest an association between reported fatigue and experiencing difficulties with physical and cognitive functions in construction workers.
Key words	Cognitive function; construction workers; exhaustion; physical function; tiredness.

Introduction

Fatigue is a workplace hazard as it affects the ability to think clearly and respond appropriately and as such has been linked to workplace injury [1,2]. Construction workers are prone to fatigue as construction work typically involves heavy workloads [3], awkward working postures [4] and prolonged working hours [5]. Although a wide consensus is lacking, the concept of fatigue is broadly described as the lassitude or exhaustion of mental and physical strength that results from bodily labour or mental exertion [1]. Fatigue is a risk factor at work as it may lead to decreased motivation and vigilance [6], and consequently the potential for accidents and injuries [2]. This impact of fatigue may be more serious in construction work, where working environments are usually regarded as dynamic and risky to safety and health [7,8].

Physical function refers to a person's ability to perform normal physical activities of daily living such as walking, reaching and climbing, whereas cognitive function involves a range of intellectual processes, including perceiving, remembering, thinking and decision-making [9]. On a construction site, workers generally plan and think (i.e. exercise cognitive functions) about the tasks they will perform and use their physical strength to execute those tasks (i.e. physical function). It is plausible that limitations in physical or cognitive function may impair an individual's work performance and may even increase their risk of workplace injuries [10,11].

In view of the physical and mental nature of fatigue, it is possible that fatigue may impair physical and cognitive functions and influence health and safety adversely. Although existing studies have suggested an association between fatigue and physical and/or cognitive function in different populations [12,13], few studies have examined this relationship in the construction industry. We hypothesized that construction workers who report feeling fatigued will also report greater difficulties with physical and/or cognitive functions. Therefore, we assessed, in a convenience sample of construction workers, the association between workers' feelings of fatigue and self-reported difficulties in physical and cognitive function, while controlling for other factors including age [9], arthritis [14], psychological distress [15], smoking and alcohol consumption [16,17].

Methods

The National Health Interview Survey (NHIS) is an annual, nationally representative cross-sectional household survey of the US population, which collects information on various topics including health conditions, psychosocial status and employment. Data are collected by standardized personal household interviews conducted by trained interviewers employed by the US Bureau of the Census according to procedures specified by the National Center for Health Statistics (NCHS). We pooled 2 years' (2010–11) NHIS survey data on adults (age 18 and older) employed as construction workers.

In this study, employment was defined as having worked during the week prior to survey interview. Construction workers were selected for analyses based on their occupational title using the two-digit NHIS detailed occupational code created by the NCHS using the 2010 Standard Occupational Classification codes. Survey respondents who had their occupational variable (OCCUPN2) coded as 19 (Construction and Extraction Occupations) were included in the study. We used the occupational variable instead of the industry variables available in the NHIS in order to exclude occupations employed in the construction industry but not engaging in construction work (e.g. accountants). All the variables considered in this paper were self-reported by the survey respondents.

We assessed respondents' feeling of fatigue with one survey question: 'In the past 3 months, how often did you feel very tired or exhausted?' Response options were: never, some days, most days or every day, and we categorized responses into feeling 'never tired' (i.e. respondents who indicated 'never'), 'tired some days' (those stating 'some days') and 'tired most days to every day' (those stating either 'most days or every day'). We assessed participants' physical function through questions about their difficulties with nine daily functional activities, namely: 'By yourself and without using any special equipment, how difficult is it for you to:

1. Walk a quarter of a mile — about 3 city blocks?
2. Walk up 10 steps without resting?
3. Stand or be on your feet for about 2 hours?
4. Sit for about 2 hours?
5. Stoop, bend, or kneel?
6. Reach up over your head?
7. Use your fingers to grasp or handle small objects?
8. Lift or carry something as heavy as 10 pounds such as a full bag of groceries?
9. Push or pull large objects as heavy as 10 pounds such as a living room chair?

Respondents were given five response options that we dichotomized into either 'no difficulty with physical function' (i.e. respondents stating 'not at all difficult') or 'any difficulty with physical function' (those who indicted 'only a little, somewhat, very difficult or can't do at all').

We assessed cognitive function with the question: 'Do you have difficulty remembering or concentrating? Response options were: no difficulty, some difficulty, a lot of difficulty or unable to do this. We dichotomized responses into 'no difficulty with cognitive function' or 'any difficulty with cognitive function' (those who indicted 'some difficulty, a lot of difficulty or unable to do this').

We examined demographic details, health behaviour and health condition characteristics of the sample population to identify any correlations with the main outcome measures of difficulty with physical and cognitive functions. These variables included age, smoking status, alcohol consumption, sleep hygiene, psychological distress and arthritis at time of interview. The age of participants was categorized into 18–44 or 45 and older. Responses for smoking status were dichotomized into 'current non-smoker' (i.e. former smoker or never smoker) or 'current smoker' (i.e. 'current every day smoker' or 'current some-day smoker'). Responses for alcohol consumption were categorized into 'current non-drinker' (i.e. responses of 'Lifetime abstainer', 'Former infrequent', 'Former regular' or 'Former, unknown frequency'), 'Infrequent to light drinker' (i.e. 'Current infrequent' or 'Current light') and 'Moderate to heavy drinker' (i.e. 'Current moderate' or 'Current heavier'). Responses for the average hours of sleep in a day were dichotomized into '6 hours or less' and '7 hours or more'. Seven hours of sleep was used as the reference given that in the extant literature it is associated with the lowest levels of morbidity and mortality [18,19]. Psychological distress was assessed by the K6 Scale [20] comprising six questions about how often respondents feel sad, nervous, restless, hopeless, effortful and worthless. Responses were dichotomized into 'distress' (K6 scores of 6–29) and 'no distress' (score 30). Arthritis status was assessed by the question: 'Have you EVER been told by a doctor or other health professional

that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?' Participants could respond either yes or no.

The proportions of workers reporting difficulty with physical and cognitive functions were calculated for the overall sample and by the reported feeling of tiredness or exhaustion in the past 3 months, as well as descriptive statistics for age, health behaviours and health conditions. A chi-squared test was performed to test the difference in physical and cognitive functions for these variables. Two multivariate logistic regression models were built to predict difficulty with physical function and with cognitive function by the feeling of tiredness or exhaustion, while controlling for age, smoking status, alcohol consumption, sleep hygiene, psychological distress and arthritis status. In the logistic regression models, gender was not taken into account due to the small sample of female workers. All analyses were performed with SPSS 21 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). The protocol was determined exempt by the institutional review board of the Harvard School of Public Health.

Results

A total of 63 280 adults participated in the 2010–11 NHIS of whom 606 (0.96%) were employed as construction workers during the survey study period. The characteristics of these subjects, by physical and cognitive functions, the feeling of tiredness or exhaustion and other variables, are shown in Table 1. Among the sample, 49% reported feeling tired or exhausted some days in the past 3 months and 10% reported feeling tired or exhausted most days or every day. Twenty-two percent (135) of workers reported difficulty with physical function and 8% (50) reported difficulty with cognitive

Table 1. Socio-demographic, health conditions and tiredness/exhaustion level by physical and cognitive functions among US construction workers participating in the 2010–11 NHIS

Sample characteristics	Total number	Physical function			Cognitive function		
		Difficult, *n* (%)	Not difficult, *n* (%)	*P*-value (two-tailed)[a]	Difficult, *n* (%)	Not difficult, *n* (%)	*P*-value (two-tailed)[a]
Total	606	135 (22)	471 (78)		50 (8)	556 (92)	
Tiredness/exhaustion							
Never tired	248	28 (11)	220 (89)	<0.001	10 (4)	238 (96)	<0.01
Tired some days	299	86 (29)	213 (71)		34 (11)	265 (89)	
Tired most days to every day	59	20 (34)	39 (66)		6 (10)	53 (90)	
Age							
18–44 years old	357	46 (13)	311 (87)	<0.001	22 (6)	335 (94)	<0.05
45 years or older	249	88 (35)	161 (65)		28 (11)	221 (89)	
Gender							
Male	586	129 (22)	457 (78)	NS	50 (9)	536 (92)	NS
Female	20	5 (25)	15 (75)		0 (0)	20 (100)	
Smoking status							
Current smokers	186	46 (25)	140 (75)	NS	14 (8)	172 (93)	NS
Current non-smokers	420	88 (21)	332 (79)		36 (9)	384 (91)	
Alcohol consumption status							
Current non-drinkers	142	25 (18)	117 (82)	NS	8 (6)	134 (94)	NS
Infrequent to light drinkers	241	53 (22)	188 (78)		19 (8)	222 (92)	
Moderate to heavy drinkers	216	54 (25)	162 (75)		23 (11)	193 (89)	
Hours of sleep							
6 hours or less	186	52 (28)	134 (72)	<0.5	13 (7)	173 (93)	NS
7 hours or more	419	82 (20)	337 (80)		37 (9)	382 (91)	
Health conditions							
Psychological distress							
Distress (K6 scores: 6–29)	259	95 (37)	164 (63)	<0.001	33 (13)	226 (87)	<0.01
No distress (K6 scores: 30)	345	39 (11)	306 (89)		17 (5)	328 (95)	
Arthritis status							
Yes	67	44 (66)	23 (34)	<0.001	13 ((20)	54 (81)	<0.001
No	539	90 (17)	449 (83)		37 (7)	502 (93)	

NS, not significant.

[a]Chi-square (χ^2) was performed to test the differences in difficulty with physical and cognitive functions by tiredness/exhaustion, demographic, health behaviours and health conditions factors.

function. Chi-squared test results showed significant differences ($P < 0.05$) in reported physical and cognitive functions between workers who reported tiredness or exhaustion and those who did not. Significant differences in physical and cognitive functions were also found between different groups when categorized by age, psychological distress and arthritis status.

In the univariate logistic regression analyses, feeling 'tired some days' was significantly associated with difficulties in physical function (unadjusted odds ratio, UOR = 3.17; 95% confidence interval [CI] 1.99–5.06) and cognitive functions (UOR = 3.05; 95% CI 1.48–6.31) compared with subjects who never felt tired. In addition, workers who felt 'tired most days to every day' were significantly more likely to report difficulties with physical function (UOR = 4.03; 95% CI 2.07–7.85) but not with cognitive function (UOR = 2.69; 95% CI 0.94–7.74) compared with workers who never felt tired.

In the multivariate model examining physical function (Table 2), we found that compared with construction workers who never felt tired, those who felt 'tired some days' were significantly more likely to report difficulty with physical function (adjusted odds ratio, AOR = 2.03; 95% CI 1.17–3.51) even after controlling for confounders. Other factors associated with greater odds of reporting difficulty with physical function included age (AOR = 3.64; 95% CI 2.27–5.83), psychological distress (AOR = 4.61; 95% CI 2.77–7.66) and arthritis status (AOR = 8.25; 95% CI 4.42–15.39). In the multivariate model examining cognitive function (Table 2), we found a significantly higher probability of reporting difficulty with cognitive function in workers who felt 'tired some days' (AOR = 2.27; 95% CI 1.06–4.88) after controlling for confounders that included psychological distress (AOR = 2.47; 95% CI 1.28–4.78) and arthritis status (AOR = 2.77; 95% CI 1.32–5.82). In addition, workers feeling 'tired most days to every day' also predicted a higher probability of reporting difficulty with both physical and cognitive functions than those never [feeling] tired, but the differences were not significant.

Discussion

In this study, we found that workers who felt tired or exhausted were more likely to report difficulty with physical and cognitive function than workers who did not feel tired. This suggests that a worker's physical and mental abilities are related to their level of fatigue. In the construction research literature, some attempts have been made to examine and characterize construction workers' tiredness, fatigue or sleep loss [21,22]. However, few studies have investigated the association between tiredness and safety outcomes using empirical data. In view of the safety implications of impaired physical or cognitive function, our study suggests that tiredness or exhaustion should be assessed as part of an overall evaluation of safety risk among construction workers. This is important because it raises awareness in the construction industry where risk of any type may be tacitly understood but not openly expressed [23], possibly because the values espoused in the construction industry are traditional masculine ones, including toughness, independence and resourcefulness [23]. Reluctance to speak up about feeling tired as well as the 'tough it out' culture perpetuated

Table 2. Multivariate logistic regression models predicting self-reported difficulty with physical and cognitive function among construction workers participating in the 2010–11 NHIS

Worker characteristics	Model: physical function				Model: cognitive function			
	UOR	95% CI	AOR	95% CI	UOR	95% CI	AOR	95% CI
Tiredness/exhaustion (ref = never tired)								
Tired some days	3.17	1.99–5.06	2.03	1.17–3.51	3.05	1.48–6.31	2.27	1.06–4.88
Tired most days to every day	4.03	2.07–7.85	2.17	0.97–4.86	2.69	0.94–7.74	1.94	0.62–6.08
Age (ref = 18–44 years old)								
45 years or older			3.64	2.27–5.83			1.79	0.96–3.33
Smoking status (ref = current non-smokers)								
Current smokers			1.34	0.82–2.18			0.85	0.43–1.67
Alcohol consumption status (ref = current non-drinkers)								
Infrequent to light drinkers			1.18	0.62–2.23			1.47	0.60–3.58
Moderate to heavy drinkers			1.44	0.76–2.73			2.17	0.90–5.22
Hours of sleep (ref = 7 hours or more)								
6 hours or less			0.97	0.69–1.59			0.50	0.24–1.02
Psychological distress (ref = no distress)								
Distress			4.61	2.77–7.66			2.47	1.28–4.78
Arthritis status (ref = no arthritis)								
Yes, doctor diagnosed arthritis			8.25	4.42–15.39			2.77	1.32–5.82

Dependent variable: any difficulty with physical function, all conditions (0 = no difficulty, 1 = difficulty); difficulty with cognitive function (0 = no difficulty, 1 = difficulty).

in the construction workforce may lead to less reporting of fatigue at work.

The limitations of this study include the use of cross-sectional data and self-report measures, including one-item measures. Although there are theoretically sound reasons to assume that fatigue leads to physical and cognitive functional limitations, no solid conclusions regarding causal relationships can be made from the data derived from this pilot study. Social desirability bias might play a role in some self-report characteristics, with under-reporting of physical and cognitive difficulties, as workers need to be healthy and injury-free to work. Lastly, we could not assess whether the findings of this study are applicable to all trades in the construction workforce. The NHIS data used in this study are representative of the US non-institutionalized population and may not necessarily capture all construction trades.

Future research can expand this model to include more direct safety outcomes, such as unsafe behaviours and near misses as well as specific measures of fatigue. Many of the tasks performed on a construction site require specific procedural steps to be followed and certain levels of concentration, so a lapse in memory or focus can lead to serious injury. Additionally, reduced physical capabilities can interfere with task performance; if normal agility or strength are compromised because of fatigue, routine tasks may become hazardous.

Despite these limitations, the results of this study suggest an association between self-reported fatigue and self-reported difficulty with physical and cognitive function in construction workers. Occupational health and safety programmes should consider innovative work strategies to reduce the burden of tiredness/exhaustion in the construction industry. Information on physical and cognitive functional impairment caused by fatigue should be incorporated into employee and supervisor safety training. The fatigue measures identified in this study can be used as part of routine workplace health risk assessment. Employers using the fatigue scale could identify workers who are either mentally or physically fatigued before the start of work and reassign them to different work tasks for the day.

Although accidents, injuries and fatalities are the direct measures of safety, studies have increasingly focused on predictive measures or 'leading indicators', such as safety climate, safety audits, and individual and organizational safety performance [24]. This shift of focus has been driven by the awareness that organizational, managerial and human factors, rather than purely technical failures, are additional causes of accidents [25]. This represents a switch from 'feed-back' to 'feed-forward' control, which may reduce the need to wait for the system to fail in order to identify weaknesses and to take remedial actions [26]. In this study, we considered individual physical and cognitive functions as predictive measures of safety, based on evidence in the literature showing that difficulty with physical or cognitive function may increase risks at work. Integrating such measures into a comprehensive safety management system that includes other indicators of safety will allow for a broader examination of worksites to prevent accidents and injuries. Construction worksites are dynamic and change frequently; workers move on and off the site because tasks differ depending on the phase of construction [27]. Given this complexity in the construction industry, individual (e.g. fatigue) and organizational (e.g. safety climate) variables should be considered in conjunction with the more technical aspects of the system, including hazard identification. Construction management teams and occupational health professionals monitoring construction workers should therefore carefully consider and assess the levels of fatigue of construction workers at work.

Key points

- Construction workers who reported frequently feeling tired at work were more likely to report difficulty with physical function.
- Construction workers who reported frequently feeling tired at work were more likely to report difficulty with cognitive function.
- Fatigue should be considered a safety risk factor among construction workers.

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Conflicts of interest

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