



## Abnormal liver function and central obesity associate with work-related fatigue among the Taiwanese workers

Yu-Cheng Lin, Jong-Dar Chen, Chao-Jen Chen

Yu-Cheng Lin, Department of Occupational Medicine, Tao-Yuan General Hospital, Tao-Yuan 330, Taiwan; Institute of Occupational Medicine and Industrial Hygiene, College of Public Health, National Taiwan University, No. 17, Xu-Zhou Road, Taipei 100, Taiwan, China

Jong-Dar Chen, Department of Family Medicine and Center for Environmental and Occupational Medicine, Shin Kong Wu Ho-Su Memorial Hospital; School of Medicine, Fu Jen Catholic University, Taipei 111, Taiwan, China

Chao-Jen Chen, Department of Family Medicine, Tao-Yuan General Hospital, Tao-Yuan 330, Taiwan, China

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**Correspondence to:** Yu-Cheng Lin, Department of Occupational Medicine, Tao-Yuan General Hospital, 14F, No. 1492, Jaung-Shan Road, Tao-Yuan 330, Taiwan, China. [gphinx@gmail.com](mailto:gphinx@gmail.com)

Telephone: +886-3-3699721-2415 Fax: +886-3-3799657

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**CONCLUSION:** For apparently healthy workers, high NFR after work is not simply a subjective experience. Objective health measures, such as elevated ALT and increased waist circumference, should be carefully evaluated for the apparently healthy workers having a higher NFR after work.

**Key words:** Liver enzyme; Need for recovery after work; Obesity; Work-related fatigue

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### Abstract

**AIM:** To examine the associations between objective health indicators and high need for recovery (NFR) after work, one of the subjective presentations of work related-fatigue, among apparently healthy workers in modern workplaces.

**METHODS:** From October to December, 2007, an annual health examination was performed for the workers from an electronics manufacturing factory in Taiwan. Health records of 1216 workers with a relatively homogeneous socioeconomic status were used for analysis. The health checkups included personal and NFR scale questionnaires, physical examinations, blood tests for biochemistry and hematology. The workers within the top tertile NFR score were defined as high-NFR workers.

**RESULTS:** After adjusted for potential confounders, the workers with elevated alanine aminotransferase (ALT) and central obesity had a significantly higher NFR after work, with increased risks of 1.4-fold [95% confidence interval (CI) = 1.01-2.0] and 1.8-fold (95% CI = 1.2-2.7), respectively. Shiftworkers had a 2.0-fold (95% CI = 1.5-2.6) increased risk for high-NFR. The associations between high-NFR and lipid profiles, blood sugar, hematology indexes or blood pressure were insignificant after controlling for confounders.

### INTRODUCTION

Work-related fatigue is a common complaint encountered by the occupational physician in the industrialized societies<sup>[1-3]</sup>. Most past investigations of work-related fatigue focused on age<sup>[4]</sup>, subjective discomforts, social-economical factors<sup>[3,5]</sup> or on work styles<sup>[6]</sup>. However, the associations between work-related fatigue and general objective health measures, such as liver function tests, metabolic syndrome components (waist circumference, blood pressure, sugar and lipids profile) or hematology test results are yet to be declared among the modern workplaces in Taiwan. Since most factories in Taiwan provide routine health check-ups for their workers, we had the opportunity to examine the association between work-related fatigue and the objective health measures.

The need for recovery (NFR) scale questionnaire is a validation tool used for the evaluation of work-related fatigue<sup>[4,7,8]</sup>. In the present study, we surveyed the potential risk factors for work-related fatigue by utilizing NFR scale questionnaire and health examination records. The records were collected from the workers of an electronics manufacturing factory. All the participants had similar salary and educational levels. Our focus was put on the association between the NFR after

work and the objective health measures. Data analyses were controlled for the confounders of gender, age, working years, smoking status, shiftwork, liver function, hematology tests and metabolic syndrome components.

## MATERIALS AND METHODS

### Participants

Most of the blue collar workers in this electronics manufacturing factory were residents of north Taiwan, aged from 23 to 56 years. These workers took periodic health checkups according to the Labor Health Protection Regulation of the Labor Safety and Health Act. The exclusion criteria of our analysis were workers' records with a past medical history of malignancy, uncompleted questionnaire or any illness on the day of health checkups. This periodic health examination was performed at the healthcare unit in the workplace between October and December, 2007. All the health examinees were suggested to avoid drastic physical exercises, such as long-distance (marathon or endurance) running, heavy weight lifting training, within 3 d before the health checkups. The records of 1216 eligible apparently healthy workers were collected for the final analysis.

### Methods

The 11-item NFR scale questionnaire containing yes/no questions representing short-term effects of a day of work<sup>[8]</sup> was translated into Chinese and then conducted by three trained nurses at the start of health examinations. The NFR scale score was calculated by adding the individual's scores on the 11 recoded items, and transformed into a scale ranging 0-100<sup>[9]</sup>. A higher scale score indicates a higher degree of NFR after work (high-NFR). For calculating relative risks, the scale scores were divided into tertiles. Workers within the top tertile NFR scale score were defined as high-NFR workers or as suffering from work-related fatigue. A questionnaire about personal history, including current smoking (recent one year and more than one pack consumed a day: Yes *vs* no), shiftwork involving night duty (yes *vs* no) was completed by the examinees.

The physical examination records used for analysis included measurements of waist circumference, weight, height and blood pressure. The definition of central obesity was waist circumference > 90 cm for males and > 80 cm for females, based on the Taiwanese criteria<sup>[10]</sup>. Elevated blood pressure was defined as systolic blood pressure (SBP)  $\geq$  130 mmHg or diastolic blood pressure (DBP)  $\geq$  85 mmHg<sup>[11]</sup>. The biochemistry blood tests for analysis included: Aspartate aminotransferase (AST), alanine aminotransferase (ALT), fasting plasma glucose, levels of triglyceride, and high-density lipoprotein (HDL) cholesterol. Elevated ALT was defined as > 40 U/mL, according to the standard reference limits used at the Tao-Yuan General Hospital and other studies<sup>[12,13]</sup>. The definitions of hyperglycemia, hypo-HDL cholesterolemia and hypertriglyceridemia were fasting sugar  $\geq$  100 mg/dL, HDL < 40 mg/dL for males or HDL < 50 mg/dL for females and triglyceride  $\geq$  150 mg/dL based on

Table 1 Baseline data and distribution of characteristics

Characteristic/Potential risk factor	Total (n = 1216)
NFR score	27.8 (21.6)
Age (yr)	34.6 (7.1)
Working year (yr)	9.1 (6.5)
Blood tests	
ALT (U/dL)	31.5 (31.8)
AST (U/dL)	23.4 (16.1)
HDL-cholesterol (mg/dL)	56.2 (12.4)
Triglyceride (mg/dL)	122.3 (81.8)
Fasting blood sugar (mg/dL)	91.6 (22.1)
Hemoglobin (mg/dL)	14.7 (1.6)
White blood count ( $\times 10^3$ /mL)	6.3 (1.7)
Anthropometric measures	
Waist (cm)	81.0 (11.1)
Body mass index (kg/m <sup>2</sup> )	24.3 (3.8)
Systolic blood pressure (mmHg)	124.9 (15.8)
Diastolic blood pressure (mmHg)	80.5 (11.5)
Male gender n (%)	852 (70)
Shiftwork n (%)	400 (33)
Smoking <sup>1</sup> n (%)	126 (11)
Blood tests	
Abnormal ALT n (%)	249 (21)
Hypo-HDL <sup>2</sup> n (%)	134 (11)
Hypertriglyceridemia <sup>2</sup> n (%)	309 (25)
Elevated fasting blood sugar <sup>2</sup> n (%)	167 (14)
Anemia <sup>3</sup> n (%)	29 (2)
Anthropometric measures	
Central obesity <sup>2</sup> n (%)	274 (23)
Elevated blood pressure <sup>2</sup> n (%)	543 (45)

Abnormal ALT: > 40 mg/dL. <sup>1</sup>Recent one year and more than one pack a day: Yes *vs* no; <sup>2</sup>Taiwanese metabolic syndrome criteria; <sup>3</sup>Significant anemia: Hb < 11 for females or < 12 mg/dL for males.

the modified ATPIII criteria<sup>[11]</sup>. Significant anemia was defined as hemoglobin (Hb) < 11 for females or < 12 for males<sup>[14]</sup>.

Student's *t*-test was used to analyze the continuous variables. Cochran-Armitage trend test was used for analyzing the categorical variables among NFR score tertiles. Multivariate logistic regression was utilized to examine the association between high-NFR and potential risk factors. SAS version 8.0 (SAS Institute, Cary, NC, USA) was used for all statistical analyses.

## RESULTS

The records of a total of 1216 workers (852 males, 364 females) were used for the final analysis. Thirty-three percent of participants in this study were shiftworkers. The overall characteristics and abnormal prevalence rates are summarized in Table 1. The mean age, working years and NFR score for this population were 34.6 years, 9.1 years and 27.8, respectively. The prevalence of elevated ALT, hypo-HDL cholesterolemia, elevated triglyceride, elevated fasting sugar, significant anemia, central obesity, elevated blood pressure and current smoking were 21%, 19%, 25%, 14%, 2%, 23%, 45% and 11%, respectively.

The objective health measures were compared according to the NFR scale score tertiles (Table 2). From the bottom to the top tertile NFR scale scores (means, 6.8, 22.4 and 52.6), ALT (29.2, 31.2 and 34.0 U/dL) and HDL cholesterol (57.6, 56.0 and 55.1 mg/dL) were significantly

Table 2 Distribution of potential risk factors according to the NFR after work score

Potential risk factor	NFR Tertiles			<i>P</i> <sup>1</sup>
	1st tertile ( <i>n</i> = 409)	2nd tertile ( <i>n</i> = 379)	3rd tertile ( <i>n</i> = 428)	
NFR score	6.8 (3.9)	22.4 (4.5)	52.6 (15.4)	-
AGE (yr)	34.6 (7.2)	34.3 (7.1)	34.8 (6.9)	0.571
Working year (yr)	8.9 (6.9)	8.7 (6.3)	9.5 (6.4)	0.251
Blood tests				
ALT (U/dL)	29.2 (22.4)	31.2 (27.3)	34.0 (41.6)	0.035
AST (U/dL)	22.4 (8.9)	23.3 (14.2)	24.4 (21.9)	0.092
HDL-cholesterol (mg/dL)	57.6 (12.9)	56 (12.4)	55.1 (11.8)	0.004
Triglyceride (mg/dL)	120.6 (76.9)	121.7 (82.7)	124.5 (85.5)	0.489
Fasting blood sugar (mg/dL)	92.3 (28.1)	90.8 (14.1)	91.7 (21.3)	0.725
Hemoglobin (mg/dL)	14.7 (1.6)	14.6 (1.6)	14.7 (1.5)	0.898
White blood count ( $\times 10^3$ /mL)	6.3 (1.9)	6.4 (1.6)	6.3 (1.6)	0.566
Anthropometric measures				
Waist (cm)	80.7 (10.8)	80.9 (11.2)	81.4 (11.6)	0.394
Body mass index (kg/m <sup>2</sup> )	24.2 (3.7)	24.2 (4)	24.4 (3.8)	0.413
Systolic blood pressure (mmHg)	124.8 (15.3)	125.6 (16.3)	124.3 (15.9)	0.678
Diastolic blood pressure (mmHg)	80.1 (11.6)	80.9 (11.5)	80.4 (11.4)	0.725
Male gender <i>n</i> (%)	300 (73)	258 (68)	294 (69)	0.072
Shiftwork <i>n</i> (%)	87 (22)	125 (33)	188 (44)	< 0.001
Smoking <sup>2</sup> <i>n</i> (%)	32 (8)	38 (10)	56 (13)	0.007
Blood tests				
Abnormal ALT <i>n</i> (%)	70 (17)	78 (21)	101 (24)	0.010
Hypo-HDL <sup>3</sup> <i>n</i> (%)	44 (11)	39 (10)	51 (12)	0.294
Hypertriglyceridemia <sup>3</sup> <i>n</i> (%)	103 (25)	91 (24)	115 (27)	0.285
Elevated fasting blood sugar <sup>3</sup> <i>n</i> (%)	58 (14)	51 (14)	58 (14)	0.397
Anemia <sup>4</sup> <i>n</i> (%)	11 (3)	10 (3)	8 (2)	0.217
Anthropometric measures				
Central obesity <sup>3</sup> <i>n</i> (%)	84 (21)	76 (20)	114 (27)	0.017
Elevated blood pressure <sup>3</sup> <i>n</i> (%)	169 (41)	186 (49)	188 (44)	0.232

Abnormal ALT: > 40 mg/dL. <sup>1</sup>*P* of student's *t*-test between the top- vs bottom-NFR tertile for the continuous variables; Cochran-Armitage Trend Test for categorical variables among tertiles; <sup>2</sup>Recent one year and more than one pack a day: *Yes* vs *no*; <sup>3</sup>Taiwanese metabolic syndrome criteria; <sup>4</sup>Significant anemia: Hb < 11 for females or < 12 mg/dL for males.

unfavorable in the top-tertile, in contrast to the subjects within the bottom-tertile of NFR scale score. The means of triglyceride (120.6, 121.7 and 124.5 mg/dL), AST (22.4, 23.4 and 24.2 U/dL), BMI (24.2, 24.2 and 24.4 kg/m<sup>2</sup>) and waist circumference (80.7, 80.9 and 81.4 cm) were unfavorable in the top-tertile, but did not reach a statistical significance. The prevalence rates of elevated ALT (17%, 20% and 27%; *P* = 0.010), central obesity (21%, 20% and 26%; *P* = 0.017) and the percentages of shiftwork (22%, 33% and 44%; *P* < 0.001), smoking (8%, 10% and 13%; *P* = 0.007) rose along with the increased NFR scale scores. The abnormal rates of significant anemia and the other metabolic syndrome components were insignificantly different among workers stratified by tertiles of the NFR scale score.

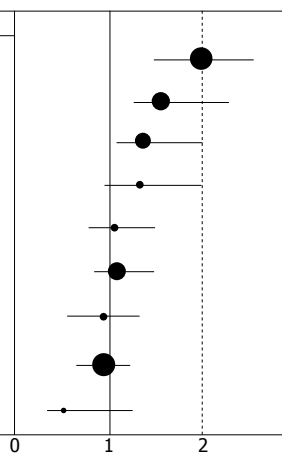
As demonstrated in Figure 1, after controlling for confounders, shiftworkers had a 2.0-fold [95% confidence interval (CI) = 1.5-2.6], centrally obese employees had a 1.8-fold (95% CI = 1.2-2.7) and the workers with elevated ALT had a 1.4-fold (95% CI = 1.01-2.0) increased risk of high NFR. Smokers had a 1.4-fold increased risk of high-NFR, though we could not confirm its statistical significance (95% CI = 0.9-2.1). Anemic status and metabolic syndrome components, except for central obesity, could not be demonstrated to have a statistically significant association with high-NFR from the present analysis of our early-middle-aged workers.

## DISCUSSION

To our knowledge, this is the first observation from the electronics manufacturing industry to report that the apparently health workers with elevated serum ALT, an objective measure for liver function<sup>[13]</sup>, require a significantly higher NFR after work. Liver function impairment has been suggested to be a developer of oxidative stress<sup>[12,15-17]</sup>, and its levels are raised among patients with chronic fatigue syndrome and associated with clinical symptoms<sup>[18-20]</sup>. In the general Taiwanese, elevated serum ALT is prevalent and predominantly caused by asymptomatic chronic hepatitis infection, steatohepatitis<sup>[21]</sup> or by hepatic toxic chemical exposure in some workplaces<sup>[22]</sup>. The present findings might motivate further studies on the relationships between each etiological entity of elevated ALT and work-related fatigue. Since liver problems are prevalent in Taiwan and elevated ALT is closely connected to high-NFR in our workers, careful liver function evaluations should be performed for those apparently healthy workers with work-related fatigue in the modern workplaces.

Central obesity was found to be an independent risk factor for a significantly higher NFR in our multivariate risk analysis. A similar phenomenon has been observed in many studies of fatigue and self-reported fatigue is associated with a higher waist circumference among Western adults<sup>[23,24]</sup>. Physical fatigue of healthy adults is

Risk factor	OR <sup>1</sup>	95% CI	P
Shiftwork	2.0	1.5-2.6	< 0.001
Central obesity <sup>2</sup>	1.8	1.2-2.7	0.003
Abnormal ALT <sup>3</sup>	1.4	1.01-2.0	0.044
Smoking <sup>4</sup>	1.4	0.9-2.0	0.103
Hypo-HDL <sup>2</sup>	1.1	0.7-1.6	0.756
Hypertriglyceridemia <sup>2</sup>	1.1	0.8-1.5	0.616
Elevated fasting blood sugar <sup>2</sup>	0.9	0.6-1.3	0.478
Elevated blood pressure <sup>2</sup>	0.9	0.6-1.1	0.269
Anemia <sup>5</sup>	0.4	0.1-1.1	0.076



**Figure 1 Odds ratio of risk factors for high NFR after work among workers, analyzed using logistic regression.** Size of dark circle represents approximate overall prevalence for each risk factor.

<sup>1</sup>Odds ratio adjusted for age, gender, working years, metabolic syndrome components, liver function test, anemia and smoking status; <sup>2</sup>Taiwanese metabolic syndrome criteria; <sup>3</sup>Alanine aminotransferase > 40 mg/dL; <sup>4</sup>Recent one year and more than one pack a day: Yes vs no; <sup>5</sup>Significant anemia: Hb < 11 for females or < 12 mg/dL for males.

associated with obesity independent of psychological factors<sup>[25]</sup>, and visceral obesity related sleep apnea can result in general fatigue<sup>[26]</sup>. Whether waist circumference reduction helps our workers to moderate the work-related fatigue is worthy of subsequent exploration.

The high-NFR workers in our analysis had a significant larger percentage of doing shiftwork. As one of the independent risk factors for high-NFR, shiftwork carries the highest odds ratio for high-NFR when compared with the other risk factors. In our analysis, no significant association was observed between shiftwork and obesity or elevated ALT. Since previous studies of work style have highlighted the adverse effects of shiftwork on workers' physical and mental health, shiftworkers must adapt their life pattern to shiftwork styles, which can result in an increased fatigue level, or even illnesses<sup>[27-29]</sup>. Since shiftwork style is common in the electronics manufacturing industry and it was reported that fatigued workers are at a high risk of being injured in occupational accidents<sup>[2]</sup>, the shiftworkers' health and safety should be emphasized in our modern workplaces. Our analysis did not address the linkage of high-NFR and shiftwork patterns, such as clockwise *vs* anticlockwise patterns, interval of shifts, or working hours in a shift. Further detailed investigations should be necessary.

Smoking, or even exposure to second-hand smoke, has been identified as a risk factor for fatigue in adults<sup>[30,31]</sup>. The present result also indicates that the percentage of current heavy smoking among the high-NFR workers was significantly greater than that in the low-NFR workers. However, the prevalence rate of smoking was lower in our study than in other studies<sup>[32]</sup>, and the analysis for smoking merely demonstrated an insignificantly increased risk for high-NFR. A partial reason may be that we emphasized more than one pack of cigarettes consumed per day in our self-report questionnaires, so that we might have failed to take account of other smokers consuming less than one pack per day and underrated the risk of work-related fatigue in smokers. Further studies about work-related fatigue associated with smoking might take into consideration all the subjects' exposure to smoke.

One of the limitations of our study is that we did not survey the job types, work titles or leisure-time physical activity included in the study, thus we could not answer the

question that workers differ in terms of physical activity that may influence both risks of central obesity and fatigue. The majority of participants in this study were early-middle-aged (mean age, 34.6 years). However, there are many different characteristics between younger and older workers in the NFR after work<sup>[4]</sup>. The present analysis results for a younger population may underestimate the impact of aging-related risk factors including metabolic syndrome on work-related fatigue<sup>[5,33]</sup> and our findings from a mostly male worker population may lack power for women, thus, some applications of our conclusion to the general working population should be cautious.

In conclusion, for the apparently healthy workers, high NFR after work is not simply a subjective experience. Objective measures such as elevated ALT and increased waist circumference are significantly associated with high NFR after work for the apparently healthy workers. We suggest that careful evaluations should focus on abnormal liver function and central obesity for those apparently healthy workers with higher NFR after work in the modern workplaces. Further studies should address if the prevalence of risk factors, particularly central obesity and elevated ALT, would reduce the risk of work-related fatigue.

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## COMMENTS

### Background

Work-related fatigue is a common complaint encountered by the occupational physician in industrialized societies. The associations between work-related fatigue and general objective health measures such as liver function tests, metabolic syndrome components (waist circumference, blood pressure, sugar and lipids profile) or hematology test results are yet to be declared among the modern workplaces.

### Research frontiers

The need for recovery (NFR) scale questionnaire is a validation tool used for the evaluation of work-related fatigue. In the present study, the authors surveyed the potential risk factors for work-related fatigue by utilizing NFR



scale questionnaire and health examination records. Their focus was put on the association between the NFR after work and the objective health measures.

### Innovations and breakthroughs

The workers with elevated alanine aminotransferase (ALT) and central obesity had a significantly higher NFR after work, with increased risks of 1.4-fold [95% confidence interval (CI) = 1.01-2.0] and 1.8-fold (95% CI = 1.2-2.7), respectively.

### Applications

The authors suggest that careful evaluations should focus on abnormal liver function and central obesity for those apparently healthy workers with a higher NFR in the modern workplaces. Reducing the prevalence of risk factors, particularly central obesity and elevated ALT, might reduce the risk of work-related fatigue.

### Terminology

The 11-item NFR scale questionnaire containing yes/no questions, representing short-term effects of a day of work, is used for the evaluation of work-related fatigue.

### Peer review

This article supports previous reports in the literature relating liver function to fatigue in the workplace. The significant results about work-related fatigue of this study for ALT and obesity are after adjusting for potential confounders.

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