ISSN 1949-8462 (online)

World Journal of *Cardiology*

World J Cardiol 2024 December 26; 16(12): 673-786

Published by Baishideng Publishing Group Inc

World Journal of Cardiology

Contents

Monthly Volume 16 Number 12 December 26, 2024

ABOUT COVER

Editorial Board Member of *World Journal of Cardiology*, Massimo Iacoviello, MD, PhD, Associate Professor, Doctor, Department of Medical and Surgical Sciences, University of Foggia, Foggia 71122, Italy. massimo.iacoviello@unifg.it

AIMS AND SCOPE

The primary aim of *World Journal of Cardiology* (*WJC*, *World J Cardiol*) is to provide scholars and readers from various fields of cardiology with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJC mainly publishes articles reporting research results and findings obtained in the field of cardiology and covering a wide range of topics including acute coronary syndromes, aneurysm, angina, arrhythmias, atherosclerosis, atrial fibrillation, cardiomyopathy, congenital heart disease, coronary artery disease, heart failure, hypertension, imaging, infection, myocardial infarction, pathology, peripheral vessels, public health, Raynaud's syndrome, stroke, thrombosis, and valvular disease.

INDEXING/ABSTRACTING

The *WJC* is now abstracted and indexed in Emerging Sources Citation Index (Web of Science), PubMed, PubMed Central, Scopus, Reference Citation Analysis, China Science and Technology Journal Database, and Superstar Journals Database. The 2024 Edition of Journal Citation Reports® cites the 2023 journal impact factor (JIF) for *WJC* as 1.9; JIF without journal self cites: 1.9; 5-year JIF: 2.3; JIF Rank: 125/222 in cardiac and cardiovascular systems; JIF Quartile: Q3; and 5-year JIF Quartile: Q2. The *WJC*'s CiteScore for 2023 is 3.3 and Scopus CiteScore rank 2023: Cardiology and cardiovascular medicine is 189/387.

RESPONSIBLE EDITORS FOR THIS ISSUE

Production Editor: *Wen-Bo Wang*; **Production Department Director:** *Xiang Li*; **Cover Editor:** *Yun-Xiaojiao Wu*.

NAME OF JOURNAL
World Journal of Cardiology

ISSN
ISSN 1949-8462 (online)

LAUNCH DATE
December 31, 2009

FREQUENCY
Monthly

EDITORS-IN-CHIEF
Ramdas G Pai, Dimitrios Tousoulis, Marco Matteo Ciccone, Pal Pacher

EDITORIAL BOARD MEMBERS
https://www.wjgnet.com/1949-8462/editorialboard.htm

PUBLICATION DATE
December 26, 2024

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

WJC World Journal of Cardiology

Submit a Manuscript: https://www.f6publishing.com

World J Cardiol 2024 December 26; 16(12): 751-759

DOI: 10.4330/wjc.v16.i12.751

ISSN 1949-8462 (online)

ORIGINAL ARTICLE

Observational Study

Nocturnal sentry duty and cardiometabolic characteristics in armed forces personnel

Yen-Po Lin, Yi-Chiung Hsu, Ko-Huan Lin, Kun-Zhe Tsai, Chen-Chih Chu, Yen-Chen Lin, Gen-Min Lin

Specialty type: Cardiac and cardiovascular systems

Provenance and peer review: Unsolicited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's classification

Scientific Quality: Grade B, Grade C

Novelty: Grade B, Grade B

Creativity or Innovation: Grade B, Grade B

Scientific Significance: Grade C, Grade C

P-Reviewer: Niazi NUK; Zhong G

Received: March 26, 2024

Revised: September 8, 2024

Accepted: October 8, 2024

Published online: December 26, 2024

Processing time: 245 Days and 0.8 Hours

Yen-Po Lin, Department of Critical Care Medicine, Taipei Tzu Chi General Hospital, New Taipei City 23142, Taiwan

Yen-Po Lin, Yi-Chiung Hsu, Department of Biomedical Sciences and Engineering, National Central University, Taoyuan City 320, Taiwan

Ko-Huan Lin, Department of Psychiatry, Hualien Tzu Chi Hospital, Hualien City 970, Taiwan

Kun-Zhe Tsai, Department of Stomatology of Periodontology, Mackay Memorial Hospital, Taipei 104, Taiwan

Kun-Zhe Tsai, Department of Dentistry, Tri-Service General Hospital, Taipei 114, Taiwan

Chen-Chih Chu, Gen-Min Lin, Department of Medicine, Tri-Service General Hospital, Taipei 114, Taiwan

Yen-Chen Lin, Department of Medicine, Linkou Chang Gung Memorial Hospital, Taoyuan City 333, Taiwan

Gen-Min Lin, Department of Medicine, Hualien Armed Forces General Hospital, Hualien City 970, Taiwan

Corresponding author: Gen-Min Lin, FACC, FAHA, FESC, MD, PhD, Academic Fellow, Chief Physician, Department of Medicine, Hualien Armed Forces General Hospital, No. 100 Jinfeng Street, Hualien City 970, Taiwan. farmer507@yahoo.com.tw

Abstract

BACKGROUND

Sleep deprivation can lead to increased body weight and blood pressure (BP), but the latent effects of partial sleep deprivation related to required night sentry duties within a short-term period on cardiometabolic characteristic changes in military personnel are unclear.

AIM

To investigate the association between night sentry duty frequency in the past 3 months and cardiometabolic characteristics in armed forces personnel.

METHODS

A total of 867 armed forces personnel who were aged 18-39 years and did not take any antihypertensive medications in Taiwan in 2020 were included. The frequency of night sentry duty was self-reported *via* a questionnaire (average number of night sentry shifts per month for the past 3 months). Hemodynamic status was assessed *via* the resting BP and pulse rate (PR). Cardiometabolic risk factors were defined according to the International Diabetes Federation criteria. Multivariable linear regression analyses of the associations between night sentry duties and PR, BP, and other metabolic syndrome (MetS) marker levels were performed, with adjustments for age, sex, substance use, body mass index and aerobic fitness. Multiple logistic regression analysis was carried out to determine the associations between night sentry duties and the prevalence of each MetS feature.

RESULTS

There was an association between night sentry duties and PR [standardized β (standard error) = 0.505 (0.223), *P* =0.02], whereas there was no association with systolic and diastolic BP. In addition, there was an inverse association between night sentry duties and high-density lipoprotein cholesterol (HDL-C) levels [standardized β = -0.490 (0.213), *P* = 0.02], whereas there was no association with the other metabolic marker levels. Compared with personnel without night sentry duties, those with ≥ 1 night sentry shift/month had a greater risk of impaired fasting glucose (≥ 100 mg/dL) [odds ratio: 1.415 (confidence interval: 1.016-1.969)], whereas no associations with other MetS features were found.

CONCLUSION

Among military personnel, the burden of night sentry duty was positively associated with the resting PR but inversely associated with HDL-C levels. In addition, personnel with partial sleep deprivation may have a greater risk of impaired fasting glucose than those without partial sleep deprivation.

Key Words: Armed forces personnel; Cardio-metabolic characteristics; Night sentry duty; Partial sleep deprivation

Core Tip: This study examined the associations between the mean frequency of night sentry duty in the past 3 months and cardiometabolic characteristics in armed forces personnel. We found an association between the frequency of night sentry duty and pulse rate [PR, standardized β (standard error) = 0.505 (0.223), *P* = 0.02] and an inverse association with high-density lipoprotein cholesterol levels [standardized β = -0.490 (0.213), *P* = 0.02], whereas there was no association with systolic or diastolic blood pressure or other metabolic biomarker levels. In addition, personnel with ≥ 1 night shift/month had a greater risk of impaired fasting glucose. In conclusion, the latent effects of partial sleep deprivation in military personnel may increase the resting PR and lead to metabolic abnormalities.

Citation: Lin YP, Hsu YC, Lin KH, Tsai KZ, Chu CC, Lin YC, Lin GM. Nocturnal sentry duty and cardiometabolic characteristics in armed forces personnel. *World J Cardiol* 2024; 16(12): 751-759

URL: https://www.wjgnet.com/1949-8462/full/v16/i12/751.htm

DOI: https://dx.doi.org/10.4330/wjc.v16.i12.751

INTRODUCTION

Sleep deprivation, also known as sleep insufficiency, is defined as an inadequate quality and/or duration of sleep to support decent performance, alertness and health[1]. In the U.S., sleep deprivation is estimated to affect one-third of Americans, with an increased prevalence in recent years[2]. Sleep deprivation can cause unstable moods, such as erratic behavior, anxiety, depression and irritability, and lead to poor cognitive function and psychotic episodes[3-5]. In addition, insufficient sleep has been linked to adverse somatic changes, *e.g.*, obesity, diabetes, increased blood pressure (BP) and heart rate, and cardiovascular diseases[6-10]. These psychosomatic adverse effects of sleep deprivation may be related to the sympathetic nervous system[11] and hypothalamic-pituitary-adrenal system activation[12]. However, most of these previous studies highlighted the effects of total sleep deprivation, whereas few studies have investigated the effects of partial sleep deprivation, which is characterized by short-term interruptions (2-3 hours) during sleep at night, with a frequency of less than twice a week.

Armed forces personnel experience greater mental stress and receive regular training to maintain superior physical fitness. On military bases, armed forces personnel are required to take night sentry shifts with a span of a few hours, which interrupts their sleep at night. It is estimated that the frequency of night sentry duty for armed forces personnel in Taiwan is approximately once per week. In the United States and Taiwan, the prevalence of overweight or obesity and metabolic syndrome (MetS) has increased to over 40% among all military personnel[13,14]. Since the latent effects of partial sleep deprivation on cardiometabolic abnormalities are unclear, this study aimed to clarify the associations of night sentry duties with hemodynamic and metabolic characteristics in military personnel, who have rarely been investigated in Taiwan or other regions.

MATERIALS AND METHODS

Study population

This cross-sectional study included 867 military participants from the ancillary Cardiorespiratory Fitness and Health in Armed Forces sleep study conducted in Taiwan in 2020. The ancillary study has been described in detail previously[15,16]. In summary, this study aimed to examine the sleep behaviors and comorbidities of military personnel and their associations with cardiometabolic health. Those with any antihypertensive, lipid-lowering or antidiabetic medication use were excluded from this study. The study design was approved by the Ethics Committee of the Mennonite Christian Hospital (No. 16-05-008), Hualien City, Taiwan, and was performed in accordance with the Helsinki Declaration, as revised in 2013. All participants were informed of the protocol of this study and provided written informed consent.

Night sentry duty assessment

The participants responded to a questionnaire concerning their frequency of night sentry duty (days per month) in the past 3 months, which was reported as 0, 1, 2, 3, 4, or 5 days. The span of each night sentry shift was limited to 2-4 hours, which was between a quarter and a half of the total nocturnal sleep time (8 hours) according to the regulation of each military base. Participants who had to work at night and had total nocturnal sleep deprivation were excluded from this study.

Definitions of cardio-metabolic characteristics

The participants were asked to have an uninterrupted nocturnal sleep duration of 8 hours and fast without any caffeine-containing or sympathomimetic agent use for longer than 12 hours before the health examination in 2020. The participants' BPs and pulse rates (PRs) were measured once on the right upper arm by an automatic device *via* the oscillometric method (FT201 Parama-Tech Co., Ltd., Fukuoka, Japan) after a 15-minute rest period and with the participant in a seated position[17-20]. If the initial systolic BP level was ≥ 130 mmHg and/or diastolic BP was ≥ 80 mmHg, a second BP measurement was performed, and the final BP level was defined as the average of the initial and second BP measurements. In addition, if the initial PR was < 50 beats/min or ≥ 100 beats/min, the participant was asked to take a second break for 15 minutes, and the PR was rechecked directly by a physician for one minute, which was treated as the final value. Echocardiography was performed to assess the left ventricular mass (LVM), left ventricular ejection fraction (LVEF) and left atrium (LA) diameter according to the latest United States guidelines[21] in selected participants (n = 280).

According to the International Diabetes Federation's criteria for Chinese individuals[21], MetS is defined as having three or more of the following clinical features: (1) Central obesity defined by a waist circumference (WC) ≥ 80 cm for women and ≥ 90 cm for men; (2) An impaired fasting plasma glucose (FPG) level ≥ 100 mg/dL; (3) Hypertriglyceridemia defined by a plasma triglyceride level ≥ 150 mg/dL; (4) A high-density lipoprotein cholesterol (HDL-C) level < 50 mg/dL for women and < 40 mg/dL for men; and (5) Hypertension defined by a systolic BP ≥ 130 mmHg and/or a diastolic BP ≥ 85 mmHg at rest[22]. Triglyceride, FPG, and HDL-C levels were analyzed *via* an automated analyzer (Olympus AU640, Kobe, Japan)[23-25].

Covariates

The body height and body weight of each participant were measured while they were standing during the health examination in 2020. Body mass index (BMI) was defined as the body weight (kg) divided by the body height squared (m^2). Body surface area was calculated to assess the LVM index according to the Dubois formula[26]. The participants self-reported their habits for substance use, such as smoking, betel nut chewing and alcohol consumption (active *vs* former/never)[27,28]. Notably, betel nut consumption is prevalent in Southeastern Asian individuals and has been associated with several metabolic disorders[29,30]. In addition, the aerobic fitness of each participant was evaluated *via* the time to complete a 3000-m run test following the health examination in the same year.

Statistical analysis

The clinical characteristics of the participants who were classified into 3 groups by night sentry duty frequency (0, 1-2, and ≥ 3 shifts/month) were compared *via* the chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. For the selected participants who underwent echocardiography, the LVM index, LVEF and LA diameter were compared *via* analysis of covariance (ANCOVA), with adjustments for age, sex and systolic BP. Multivariable linear regression analyses of the associations of night sentry duty (treated as a continuous variable) with the PR, BP, and other MetS biomarkers were performed separately, with adjustments for age, sex and substance use (Model 1) and additionally for BMI and cardiorespiratory fitness (Model 2). Multivariate logistic regression analysis was carried out to determine the associations of night sentry duty (treated as a categorical variable) with the prevalence of MetS and its related features separately. The covariates in the models were selected because of their potential as contributors to MetS. Statistical analyses were performed *via* SPSS software for Windows (SPSS Inc., Chicago, IL, United States). A P value of < 0.05 was considered indicative of statistical significance.

RESULTS

Table 1 reveals the clinical characteristics of participants without night sentry shifts in the past 3 months (n = 506), those with 1-2 night sentry shifts/month (n = 220) and those with ≥ 3 night sentry shifts/month (n = 141) on the basis of their responses to the questionnaire. The mean age was approximately 28 years, and there were no significant differences in sex distribution between the groups. With respect to substance use status, participants with 0 and 1-2 night sentry shifts/ month had a greater prevalence of active cigarette smoking than did participants with ≥ 3 night sentry shifts/month. For hemodynamics, a faster PR was found in individuals with ≥ 3 night sentry shifts/month than in individuals in the other two groups, while there were no differences in systolic BP, diastolic BP, or pulse pressure, defined as "systolic BP-diastolic BP", between the groups. For BMI and metabolic biomarkers, no significant differences were found between the groups. For the echocardiographic characteristics of the selected participants, accounting for approximately one-third of the overall participants (32.3%), there were no differences in the LVM index, LVEF or LA diameter after adjustment for age, sex and systolic BP, although the mean values of the LVM index and LA diameter increased in those with a greater number of night sentry shifts/month.

Table 2 shows the results of multivariable linear regression analyses of the association of the frequency of night sentry duty with the PR and BP separately. Although there was an association between night sentry duty and diastolic BP in the crude model, there were no multivariable-adjusted associations for systolic or diastolic BP or pulse pressure. In contrast, there was an association between night sentry duty and the PR after adjustment for the potential covariates [standardized β (standard error) = 0.505 (0.223), P = 0.02 in Model 2).

Table 3 shows the results of multivariable linear regression analyses of the association of the frequency of night sentry duty with each MetS biomarker level except BP. There were no associations of night sentry duty with WC, serum triglyceride levels or FPG levels in the crude or multivariable models, whereas there was an inverse association between night sentry duty and HDL-C levels in the crude and multivariable models [standardized β = -0.490 (0.213), P = 0.02 in Model 2].

Table 4 shows the results of multivariable logistic regression analyses of the frequency of night sentry duty try duty for the prevalence of MetS and its related features. Compared with those without night sentry duties, participants with ≥ 1 night sentry shift/month were more likely to have impaired FPG [odds ratio (OR) and 95% confidence interval: 1.415 (1.016-1.969)] after adjustment for the potential covariates in Model 2. In contrast, the associations for prevalent MetS and other features were not significant. Moreover, there were no greater associations for hypertriglyceridemia or impaired FPG with a greater number of night sentry shifts. Compared with those without night sentry shifts, those with 1-2 night sentry shifts/month were more likely to have impaired FPG and hypertriglyceridemia [ORs: 1.481 (1.013-2.167) and 1.804 (1.131-2.879), respectively], which were greater than the association magnitudes in those with ≥ 3 night sentry shifts/ month [ORs: 1.316 (0.839-2.062) and 1.053 (0.580-1.911), respectively].

DISCUSSION

The main findings of this study were that among armed forces personnel, there was a positive linear association between night sentry duty and the resting PR but an inverse linear association with HDL-C levels. In addition, participants with any night sentry shifts within a month may have a greater risk of impaired fasting glucose than those without any night sentry shifts.

Although many studies have demonstrated an association of sleep deprivation with increased BP and hypertension, most previous studies were performed to examine the acute and chronic impacts of sleep deprivation on BP levels and hypertension[6]. In some animal model studies, chronic sleep deprivation led to cardiac remodeling and dysfunction, which were confirmed by specific gene expression[31,32]. Notably, this study is the first to investigate the latent effects of partial sleep deprivation, *e.g.*, night sentry duty, on the hemodynamic characteristics of young military personnel. This study revealed that the frequency of night sentry duty was positively associated with the PR or heart beat rather than with BP levels or hypertension. Mechanisms for the increased PR in response to acute or chronic sleep deprivation have been proposed to be associated with increased psychological stress and neurohormonal system activation[5-7]. It is possible that occasional partial sleep deprivation at night may not significantly affect the daytime resting BP or related cardiac structures and function if adequate nocturnal sleep or short-term sleep recovery follows[32]. However, the latent effect on the increased resting PR remains, which has been associated with cardiovascular health and longevity[33,34].

With respect to the latent effect of partial sleep deprivation at night on metabolic health, this study revealed a novel finding of a linear inverse association between the frequency of night sentry duty try duty frequency and HDL-C levels, which has not been previously reported. To the best of our knowledge, HDL-C levels are correlated with sex, body weight, plasma triglyceride levels, aerobic fitness, and inflammation[35-37]. The mechanisms underlying the inverse association with partial sleep deprivation are not fully understood, which may be explained in part by increased low-grade inflammation related to sleep deprivation[38]. In addition, there were greater associations for low HDL-C levels in those with a greater frequency of night shifts (ORs: 1.057 and 1.198, respectively, for 1-2 and ≥ 3 night shifts/month), which was related to the linear inverse association with HDL-C levels, despite statistical nonsignificance. In contrast, this study revealed that participants with any night shifts (≥ 1)/month had a greater possibility of impaired FPG than those without night shifts. Notably, the associations for impaired FPG were not significant; the highest probability was noted in participants with 1-2 night shifts/month, followed by those with ≥ 3 night shifts/month (ORs: 1.481 and 1.316, respectively). This finding may account for the insignificant linear associations for FPG. In a randomized crossover trial, restricting sleep to 6.2 hours or less per night, as measured by actigraphy over 6 weeks, was associated with a 14.8%

Table 1 Clinical characteristics of military participants classified by night sentry duty frequency

	Night sentry duty 0/month (*n* = 506)	Night sentry duty 1-2/month (*n* = 220)	Night sentry duty ≥ 3/month (*n* = 141)	*P* value
Age (years)	28.01 ± 6.21	28.71 ± 5.90	28.89 ± 5.82	0.17
Male, *n* (%)	434 (85.8)	199 (90.5)	129 (91.5)	0.07
Substance use, *n* (%)				
Alcohol drinking	208 (41.1)	87 (39.5)	45 (31.9)	0.14
Betel nut chewing	74 (14.6)	35 (15.9)	11 (7.8)	0.07
Cigarette smoking	252 (49.8)	108 (49.1)	51 (36.2)	0.01
Time for a 3000-m run (seconds)	906.65 ± 134.39	905.29 ± 161.73	922.10 ± 101.86	0.46
Body mass index (kg/m^2)	24.69 ± 3.99	24.57 ± 3.76	24.59 ± 3.28	0.91
Systolic BP (mmHg)	117.40 ± 14.30	117.45 ± 12.34	116.97 ± 12.52	0.93
Diastolic BP (mmHg)	69.47 ± 11.00	69.73 ± 9.11	70.27 ± 9.21	0.71
Pulse pressure (mmHg)	47.93 ± 10.55	47.72 ± 9.58	46.69 ± 9.82	0.44
Pulse rate (bpm)	73.34 ± 10.87	72.22 ± 10.68	75.03 ± 9.24	0.04
Blood test				
Total cholesterol (mg/dL)	171.21 ± 31.43	174.28 ± 35.25	171.64 ± 31.12	0.49
LDL-C (mg/dL)	104.65 ± 28.65	107.03 ± 31.02	106.98 ± 29.69	0.50
HDL-C (mg/dL)	50.80 ± 10.88	50.35 ± 10.71	48.43 ± 9.96	0.07
Serum triglycerides (mg/dL)	100.39 ± 83.01	108.85 ± 72.47	106.06 ± 82.73	0.39
Fasting glucose (mg/dL)	94.28 ± 9.15	95.09 ± 10.74	95.09 ± 9.10	0.47
Echocardiographic parameters[1]				
LVMI (g/m^2)	73.76 ± 11.91	76.00 ± 14.85	77.46 ± 13.78	0.20
LVEF (%)	61.43 ± 4.85	62.30 ± 4.93	62.81 ± 4.65	0.14
LA diameter (mm)	32.60 ± 4.48	32.65 ± 4.44	33.70 ± 4.12	0.38

[1]Participant numbers for night sentry duty: 0/month, 1-2/month, and ≥ 3/month were 154, 83 and 43, respectively, and echocardiographic parameters were compared with adjustments for age, sex and systolic blood pressure.
BP: Blood pressure; HDL-C: High-density lipoprotein cholesterol; LDL-C: Low-density lipoprotein cholesterol; LA: Left atrium; LVEF: Left ventricular ejection fraction; LVMI: Left ventricular mass index.

Table 2 Associations between night sentry duty frequency and levels of various hemodynamic parameters

	PR		SBP		DBP		PP	
	β (SE)	*P* value	β (SE)	*P* value	β (SE)	*P* value	β (SE)	*P* value
Crude model	0.558 (0.226)	0.01	0.300 (0.288)	0.29	0.482 (0.215)	0.02	-0.182 (0.221)	0.41
Model 1	0.569 (0.227)	0.01	0.054 (0.280)	0.84	0.251 (0.206)	0.22	-0.197 (0.218)	0.36
Model 2	0.505 (0.223)	0.02	0.086 (0.268)	0.74	0.266 (0.203)	0.18	-0.180 (0.214)	0.40

Data are presented as standardized β and standard error (SE) using linear regression analysis. Model 1: Age, sex, alcohol drinking, betel nut chewing, cigarette smoking adjustments. Model 2: Age, sex, alcohol drinking, betel nut chewing, cigarette smoking, body mass index and time for a run adjustment.
DBP: Diastolic blood pressure; PP: Pulse pressure; PR: Pulse rate; SBP: Systolic blood pressure.

increase in insulin resistance independent of adiposity in both pre- and postmenopausal women[8], which was consistent with the findings regarding partial sleep deprivation and the development of impaired FPG in this study. However, the effects of sleep deprivation on hypertriglyceridemia have been inconsistent in prior studies, which revealed a lower level of serum triglycerides in individuals with acute sleep deprivation[39,40], and the lipid paradox may be mediated by proinflammatory conditions[40]. Given that the latent effect of partial sleep deprivation in this study seems to have increased triglyceride levels despite borderline significance (P = 0.09 in the multivariable linear regression analysis and P

Table 3 Associations between night sentry duty frequency and levels of metabolic syndrome biomarkers

	WC		HDL-C		TG		FPG	
	β (SE)	*P* value	β (SE)	*P* value	β (SE)	*P* value	β (SE)	*P* value
Crude model	0.321 (0.231)	0.16	-0.598 (0.230)	0.009	3.094 (1.705)	0.07	0.365 (0.205)	0.07
Model 1	0.075 (0.209)	0.72	-0.493 (0.221)	0.02	2.610 (1.623)	0.10	0.212 (0.204)	0.29
Model 2	0.147 (0.112)	0.18	-0.490 (0.213)	0.02	2.613 (1.577)	0.09	0.218 (0.202)	0.28

Data are presented as standardized β and standard error (SE) using linear regression analysis. Model 1: Age, sex, alcohol drinking, betel nut chewing, cigarette smoking adjustments. Model 2: Age, sex, alcohol drinking, betel nut chewing, cigarette smoking, body mass index and time for a run adjustment. FPG: fasting plasma glucose; HDL-C: high-density lipoprotein cholesterol; TG: serum triglycerides; WC: waist circumference.

Table 4 Associations of night sentry duty frequency categories with metabolic syndrome and related features

	Hypertension	Central obesity	Reduced HDL-C	Increased TG	Impaired FPG	Metabolic syndrome
No night duty (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Night duty ≥ 1/month	1.094 (0.758-1.579)	1.110 (0.676-1.823)	1.111 (0.741-1.665)	1.487 (0.980-2.256)	1.415 (1.016-1.969)[a]	1.464 (0.873-2.456)
No night duty (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Night duty 1-2/month	1.084 (0.706-1.663)	0.991 (0.551-1.782)	1.057 (0.657-1.701)	1.804 (1.131-2.879)[a]	1.481 (1.013-2.167)[a]	1.755 (0.984-3.130)
Night duty ≥ 3/month	1.109 (0.678-1.816)	1.311 (0.672-2.555)	1.198 (0.695-2.066)	1.053 (0.580-1.911)	1.316 (0.839-2.062)	1.059 (0.509-2.202)

[a]$P < 0.05$.

Definitions: Hypertension was defined as systolic blood pressure ≥ 130 mmHg and/or diastolic blood pressure ≥ 85 mmHg; central obesity was defined as waist circumference ≥ 90 cm in men and ≥ 80 cm in women; reduced high-density lipoprotein was defined as < 40 mg/dL in men and < 50 mg/dL in women; increased serum triglycerides was defined as ≥ 150 mg/dL; impaired fasting plasma glucose was defined as ≥ 100 mg/dL; metabolic syndrome was defined as having 3 or more of the above five features. Data are presented as odds ratio (OR) and confidence interval using multiple logistic regression analysis with adjustments for age, sex, alcohol drinking, betel nut chewing, cigarette smoking, body mass index and time for a run adjustment. FPG: Fasting plasma glucose; HDL-C: High-density lipoprotein cholesterol; TG: Serum triglycerides.

= 0.08 in the multivariable logistic regression analysis), more evidence is needed to confirm the association with dyslipidemia.

There were several limitations in this study. First, this cross-sectional study could not establish causal associations. Second, the frequency of night sentry duty for each participant was assessed by a self-reported response to a questionnaire, which may not be accurate, although recall within 3 months should be acceptable. Third, this study included armed forces personnel who were required to have a regular schedule for nocturnal sleep (full time for 8 hours) for analysis; this provided the strength to unify the total sleep time at night, estimated to be 5-6 hours in those on night sentry duty, although no objective assessment for sleep time using a device for each participant was performed. Finally, obstructive sleep apnea could cause sleep deprivation, which may confound the results and lead to bias[41,42]. In contrast, there were several advantages in this study. To our knowledge, exercise training has been shown to reduce the PR and BP and improve metabolic profiles, which may attenuate the adverse effects of night sentry duty in military personnel revealed in our previous studies[43-45]. The benefits related to exercise training were also observed in military personnel in other regions and in the general population[46-49]. In this study, cardiorespiratory fitness levels were adjusted for in the models, which could largely diminish bias.

CONCLUSION

Among military personnel, night sentry duty was positively associated with the resting PR but inversely associated with HDL-C levels. Compared with those without night duties, individuals with partial sleep deprivation due to any number of night shifts per month may have a greater risk of impaired FPG, while the risk of hypertriglyceridemia was not confirmed. The clinical implications are that uninterrupted nocturnal sleep is crucial for maintaining both good hemodynamic and metabolic health, especially insulin sensitivity, in relatively healthy young adults. Sleep recovery for a few weeks following a night sentry shift should be implemented as a practical program to prevent the development of adverse hemodynamic, metabolic and cardiac dysfunction in military personnel.

FOOTNOTES

Author contributions: Lin YP and Hsu YC wrote the article and contributed equally; Lin KH collected the data; Tsai KZ analyzed the data; Chu CC and Yen-Chen Lin reviewed the data, edited and made critical revisions related to important intellectual content. Lin GM and Lin KH contributed to conception and design of the CHIEF Sleep study, and acquired and interpreted the data; all authors approved the final version of the article to be published.

Supported by Medical Affairs Bureau Ministry of National Defense, No. MND-MAB-D-113200 and Hualien Armed Forces General Hospital, No. HAFGH-D-113008.

Institutional review board statement: The study design was approved by the Ethics Committee of the Mennonite Christian Hospital (No. 16-05-008), Hualien City, Taiwan, and was performed in accordance with the Helsinki Declaration, as revised in 2013.

Informed consent statement: All participants were informed of the protocol of this study and gave written informed consent.

Conflict-of-interest statement: The authors declare that they have no conflicts of interest.

Data sharing statement: As the CHIEF study materials were obtained from the military in Taiwan, the data were confidential and not allowed to be opened in public. If there are any needs for clarification, the readers can contact Dr. Lin, the corresponding author, for sharing the data.

STROBE statement: The authors have read the STROBE Statement—checklist of items, and the manuscript was prepared and revised according to the STROBE Statement—checklist of items.

Country of origin: Taiwan

ORCID number: Yen-Po Lin 0000-0003-2798-3978; Ko-Huan Lin 0000-0001-9727-5948; Kun-Zhe Tsai 0000-0002-7126-1545; Gen-Min Lin 0000-0002-5509-1056.

S-Editor: Lin C
L-Editor: A
P-Editor: Zhao S

REFERENCES

1 **Williams TB**, Badariotti JI, Corbett J, Miller-Dicks M, Neupert E, McMorris T, Ando S, Parker MO, Thelwell RC, Causer AJ, Young JS, Mayes HS, White DK, de Carvalho FA, Tipton MJ, Costello JT. The effects of sleep deprivation, acute hypoxia, and exercise on cognitive performance: A multi-experiment combined stressors study. *Physiol Behav* 2024; **274**: 114409 [PMID: 37977251 DOI: 10.1016/j.physbeh.2023.114409]

2 **Liu Y**, Wheaton AG, Chapman DP, Cunningham TJ, Lu H, Croft JB. Prevalence of Healthy Sleep Duration among Adults--United States, 2014. *MMWR Morb Mortal Wkly Rep* 2016; **65**: 137-141 [PMID: 26890214 DOI: 10.15585/mmwr.mm6506a1]

3 **Alhola P**, Polo-Kantola P. Sleep deprivation: Impact on cognitive performance. *Neuropsychiatr Dis Treat* 2007; **3**: 553-567 [PMID: 19300585]

4 **Yuan W**, Chen L, Wu Y, Su B, Liu J, Zhang Y, Chen M, Ma Y, Guo T, Wang X, Ma T, Ma Q, Cui M, Ma J, Dong Y. Sleep time and quality associated with depression and social anxiety among children and adolescents aged 6-18 years, stratified by body composition. *J Affect Disord* 2023; **338**: 321-328 [PMID: 37343629 DOI: 10.1016/j.jad.2023.06.029]

5 **Futenma K**, Takaesu Y, Komada Y, Shimura A, Okajima I, Matsui K, Tanioka K, Inoue Y. Delayed sleep-wake phase disorder and its related sleep behaviors in the young generation. *Front Psychiatry* 2023; **14**: 1174719 [PMID: 37275982 DOI: 10.3389/fpsyt.2023.1174719]

6 **Makarem N**, Alcántara C, Williams N, Bello NA, Abdalla M. Effect of Sleep Disturbances on Blood Pressure. *Hypertension* 2021; **77**: 1036-1046 [PMID: 33611935 DOI: 10.1161/HYPERTENSIONAHA.120.14479]

7 **Pasetes LN**, Rosendahl-Garcia KM, Goel N. Impact of bimonthly repeated total sleep deprivation and recovery sleep on cardiovascular indices. *Physiol Rep* 2023; **11**: e15841 [PMID: 37849046 DOI: 10.14814/phy2.15841]

8 **Zuraikat FM**, Laferrère B, Cheng B, Scaccia SE, Cui Z, Aggarwal B, Jelic S, St-Onge MP. Chronic Insufficient Sleep in Women Impairs Insulin Sensitivity Independent of Adiposity Changes: Results of a Randomized Trial. *Diabetes Care* 2024; **47**: 117-125 [PMID: 37955852 DOI: 10.2337/dc23-1156]

9 **Akhlaghi M**, Kohanmoo A. Sleep deprivation in development of obesity, effects on appetite regulation, energy metabolism, and dietary choices. *Nutr Res Rev* 2023; 1-21 [PMID: 37905402 DOI: 10.1017/S0954422423000264]

10 **Pan Y**, Zhou Y, Shi X, He S, Lai W. The association between sleep deprivation and the risk of cardiovascular diseases: A systematic metaanalysis. *Biomed Rep* 2023; **19**: 78 [PMID: 37829258 DOI: 10.3892/br.2023.1660]

11 **Tai BWS**, Dawood T, Macefield VG, Yiallourou SR. The association between sleep duration and muscle sympathetic nerve activity. *Clin Auton Res* 2023; **33**: 647-657 [PMID: 37543558 DOI: 10.1007/s10286-023-00965-7]

12 **Vargas I**, Lopez-Duran N. Investigating the effect of acute sleep deprivation on hypothalamic-pituitary-adrenal-axis response to a psychosocial stressor. *Psychoneuroendocrinology* 2017; **79**: 1-8 [PMID: 28235691 DOI: 10.1016/j.psyneuen.2017.01.030]

13 **McLaughlin R**, Wittert G. The obesity epidemic: implications for recruitment and retention of defence force personnel. *Obes Rev* 2009; **10**: 693-699 [PMID: 19486307 DOI: 10.1111/j.1467-789X.2009.00601.x]

14 **Lin KH**, Su FY, Yang SN, Liu MW, Kao CC, Nagamine M, Lin GM. Body Mass Index and Association of Psychological Stress with Exercise Performance in Military Members: The Cardiorespiratory Fitness and Hospitalization Events in Armed Forces (CHIEF) Study. *Endocr Metab Immune Disord Drug Targets* 2021; **21**: 2213-2219 [PMID: 33906597 DOI: 10.2174/1871530321666210427090550]

15 **Lin GM**, Li YH, Lee CJ, Shiang JC, Lin KH, Chen KW, Chen YJ, Wu CF, Lin BS, Yu YS, Lin F, Su FY, Wang CH. Rationale and design of the cardiorespiratory fitness and hospitalization events in armed forces study in Eastern Taiwan. *World J Cardiol* 2016; **8**: 464-471 [PMID: 27621774 DOI: 10.4330/wjc.v8.i8.464]

16 **Liu WN**, Lin KH, Tsai KZ, Chu CC, Chang YC, Kwon Y, Lin GM. High risk for obstructive sleep apnea and risk of hypertension in military personnel: The CHIEF sleep study. *World J Clin Cases* 2023; **11**: 7309-7317 [PMID: 37969444 DOI: 10.12998/wjcc.v11.i30.7309]

17 **Lin YP**, Fan CH, Tsai KZ, Lin KH, Han CL, Lin GM. Psychological stress and long-term blood pressure variability of military young males: The cardiorespiratory fitness and hospitalization events in armed forces study. *World J Cardiol* 2020; **12**: 626-633 [PMID: 33391615 DOI: 10.4330/wjc.v12.i12.626]

18 **Lin YK**, Liu PY, Fan CH, Tsai KZ, Lin YP, Lee JM, Lee JT, Lin GM. Metabolic biomarkers and long-term blood pressure variability in military young male adults. *World J Clin Cases* 2020; **8**: 2246-2254 [PMID: 32548155 DOI: 10.12998/wjcc.v8.i11.2246]

19 **Lin GM**, Tsai KZ, Lin CS, Han CL. Physical Fitness and Long-term Blood Pressure Variability in Young Male Military Personnel. *Curr Hypertens Rev* 2020; **16**: 156-160 [PMID: 31702494 DOI: 10.2174/1573402115666191023111351]

20 **Lai SW**, Tsai KZ, Wang SH, Lin YK, Lin YP, Lin GM. Erythrocyte Indices and Long-Term Blood Pressure Variability in Military Males. *Cardiovasc Hematol Disord Drug Targets* 2021; **21**: 217-224 [PMID: 34906064 DOI: 10.2174/1871529X21666211214154545]

21 **Lin GM**, Liu K. An Electrocardiographic System With Anthropometrics *via* Machine Learning to Screen Left Ventricular Hypertrophy among Young Adults. *IEEE J Transl Eng Health Med* 2020; **8**: 1800111 [PMID: 32419990 DOI: 10.1109/JTEHM.2020.2990073]

22 **Alberti KG**, Zimmet P, Shaw J. Metabolic syndrome--a new world-wide definition. A Consensus Statement from the International Diabetes Federation. *Diabet Med* 2006; **23**: 469-480 [PMID: 16681555 DOI: 10.1111/j.1464-5491.2006.01858.x]

23 **Tsai KZ**, Huang WC, Sui X, Lavie CJ, Lin GM. Moderate or greater daily coffee consumption is associated with lower incidence of metabolic syndrome in Taiwanese militaries: results from the CHIEF cohort study. *Front Nutr* 2023; **10**: 1321916 [PMID: 38156279 DOI: 10.3389/fnut.2023.1321916]

24 **Chen YJ**, Chen KW, Shih YL, Su FY, Lin YP, Meng FC, Lin F, Yu YS, Han CL, Wang CH, Lin JW, Hsieh TY, Li YH, Lin GM. Chronic hepatitis B, nonalcoholic steatohepatitis and physical fitness of military males: CHIEF study. *World J Gastroenterol* 2017; **23**: 4587-4594 [PMID: 28740347 DOI: 10.3748/wjg.v23.i25.4587]

25 **Liu PY**, Tsai KZ, Huang WC, Lavie CJ, Lin GM. Electrocardiographic and cardiometabolic risk markers of left ventricular diastolic dysfunction in physically active adults: CHIEF heart study. *Front Cardiovasc Med* 2022; **9**: 941912 [PMID: 35966559 DOI: 10.3389/fcvm.2022.941912]

26 **Du Bois D**, Du Bois EF. A formula to estimate the approximate surface area if height and weight be known. 1916. *Nutrition* 1989; **5**: 303-11; discussion 312 [PMID: 2520314]

27 **Su FY**, Wang SH, Lu HH, Lin GM. Association of Tobacco Smoking with Physical Fitness of Military Males in Taiwan: The CHIEF Study. *Can Respir J* 2020; **2020**: 5968189 [PMID: 31998426 DOI: 10.1155/2020/5968189]

28 **Feng AC**, Tsai SC, Lin YP, Tsai KZ, Lin GM. Erythrocyte indices and localized stage II/III periodontitis in military young men and women: CHIEF oral health study. *BMC Oral Health* 2022; **22**: 404 [PMID: 36115999 DOI: 10.1186/s12903-022-02455-0]

29 **Lin YP**, Tsai KZ, Chang CY, Su FY, Han CL, Lin GM. Tobacco Smoking and Association between Betel Nut Chewing and Metabolic Abnormalities Among Military Males: The CHIEF Study. *Endocr Metab Immune Disord Drug Targets* 2021; **21**: 298-304 [PMID: 32811419 DOI: 10.2174/1871530320999200818164616]

30 **Tsai KZ**, Lin JW, Lin F, Su FY, Li YH, Lin YP, Lin YK, Han CL, Hsieh CB, Lin GM. Association of betel nut chewing with exercise performance in a military male cohort: the CHIEF study. *J R Army Med Corps* 2018; **164**: 399-404 [PMID: 30012664 DOI: 10.1136/jramc-2017-000899]

31 **Dong B**, Xue R, Li J, Ling S, Xing W, Liu Z, Yuan X, Pan J, Du R, Shen X, Zhang J, Zhang Y, Li Y, Zhong G. Ckip-1 3'UTR alleviates prolonged sleep deprivation induced cardiac dysfunction by activating CaMKK2/AMPK/cTNI pathway. *Mol Biomed* 2024; **5**: 23 [PMID: 38871861 DOI: 10.1186/s43556-024-00186-y]

32 **Zhong L**, Zhang J, Yang J, Li B, Yi X, Speakman JR, Gao S, Li M. Chronic sleep fragmentation reduces left ventricular contractile function and alters gene expression related to innate immune response and circadian rhythm in the mouse heart. *Gene* 2024; **914**: 148420 [PMID: 38556117 DOI: 10.1016/j.gene.2024.148420]

33 **Wang C**, Xin Q, Zheng M, Liu S, Yao S, Li Y, Tian L, Feng Z, Wang M, Zhao M, Chen S, Wu S, Xue H. Association of Resting Heart Rate Trajectories With Cardiovascular Disease and Mortality in Patients With Diabetes Mellitus. *J Clin Endocrinol Metab* 2023; **108**: 2981-2989 [PMID: 37084400 DOI: 10.1210/clinem/dgad228]

34 **Johansen CD**, Olsen RH, Pedersen LR, Kumarathurai P, Mouridsen MR, Binici Z, Intzilakis T, Køber L, Sajadieh A. Resting, night-time, and 24 h heart rate as markers of cardiovascular risk in middle-aged and elderly men and women with no apparent heart disease. *Eur Heart J* 2013; **34**: 1732-1739 [PMID: 23306958 DOI: 10.1093/eurheartj/ehs449]

35 **Pietrobelli A**, Lee RC, Capristo E, Deckelbaum RJ, Heymsfield SB. An independent, inverse association of high-density-lipoprotein-cholesterol concentration with nonadipose body mass. *Am J Clin Nutr* 1999; **69**: 614-620 [PMID: 10197562 DOI: 10.1093/ajcn/69.4.614]

36 **Sady SP**, Berg K, Beal D, Smith JL, Savage MP, Thompson WH, Nutter J. Aerobic fitness and serum high-density lipoprotein cholesterol in young children. *Hum Biol* 1984; **56**: 771-781 [PMID: 6530224]

37 **Jia C**, Anderson JLC, Gruppen EG, Lei Y, Bakker SJL, Dullaart RPF, Tietge UJF. High-Density Lipoprotein Anti-Inflammatory Capacity and Incident Cardiovascular Events. *Circulation* 2021; **143**: 1935-1945 [PMID: 33840204 DOI: 10.1161/CIRCULATIONAHA.120.050808]

38 **Simpson NS**, Diolombi M, Scott-Sutherland J, Yang H, Bhatt V, Gautam S, Mullington J, Haack M. Repeating patterns of sleep restriction and recovery: Do we get used to it? *Brain Behav Immun* 2016; **58**: 142-151 [PMID: 27263430 DOI: 10.1016/j.bbi.2016.06.001]

39 **Ness KM**, Strayer SM, Nahmod NG, Schade MM, Chang AM, Shearer GC, Buxton OM. Four nights of sleep restriction suppress the postprandial lipemic response and decrease satiety. *J Lipid Res* 2019; **60**: 1935-1945 [PMID: 31484696 DOI: 10.1194/jlr.P094375]

40 **Barragán R**, Zuraikat FM, Cheng B, Scaccia SE, Cochran J, Aggarwal B, Jelic S, St-Onge MP. Paradoxical Effects of Prolonged Insufficient Sleep on Lipid Profile: A Pooled Analysis of 2 Randomized Trials. *J Am Heart Assoc* 2023; **12**: e032078 [PMID: 37815115 DOI: 10.1161/JAHA.123.032078]

41 **Lin GM**, Colangelo LA, Lloyd-Jones DM, Redline S, Yeboah J, Heckbert SR, Nazarian S, Alonso A, Bluemke DA, Punjabi NM, Szklo M, Liu K. Association of Sleep Apnea and Snoring With Incident Atrial Fibrillation in the Multi-Ethnic Study of Atherosclerosis. *Am J Epidemiol* 2015; **182**: 49-57 [PMID: 25977516 DOI: 10.1093/aje/kwv004]

42 **Kwon Y**, Baruch M, Stafford PL, Bonner H, Cho Y, Mazimba S, Logan JG, Shimbo D, Park SH, Lin GM, Azarbarzin A, Calhoun DA, Berry R, Carey RM. Elucidation of obstructive sleep apnoea related blood pressure surge using a novel continuous beat-to-beat blood pressure monitoring system. *J Hypertens* 2022; **40**: 520-527 [PMID: 34751170 DOI: 10.1097/HJH.0000000000003041]

43 **Liu PY**, Tsai KZ, Lima JAC, Lavie CJ, Lin GM. Athlete's Heart in Asian Military Males: The CHIEF Heart Study. *Front Cardiovasc Med* 2021; **8**: 725852 [PMID: 34660727 DOI: 10.3389/fcvm.2021.725852]

44 **Liu MY**, Liu PY, Tsai KZ, Lima JAC, Lavie CJ, Lin GM. Asian Female Athlete's Heart: The CHIEF Heart Study. *Acta Cardiol Sin* 2023; **39**: 888-900 [PMID: 38022423 DOI: 10.6515/ACS.202311_39(6).20230306F]

45 **Lin YK**, Tsai KZ, Han CL, Lee JT, Lin GM. Athlete's Heart Assessed by Sit-Up Strength Exercises in Military Men and Women: The CHIEF Heart Study. *Front Cardiovasc Med* 2021; **8**: 737607 [PMID: 35155593 DOI: 10.3389/fcvm.2021.737607]

46 **Cardim N**. Athlete's heart and soldier's heart: Is Morganroth striking back? *Rev Port Cardiol (Engl Ed)* 2018; **37**: 257-258 [PMID: 29580672 DOI: 10.1016/j.repc.2018.03.003]

47 **Torres RE**, Heileson JL, Richardson KA, Chapman-Lopez TJ, Funderburk LK, Forsse JS. The Effectiveness of Utilizing HRV Indices as a Predictor of ACFT Performance Outcomes. *Mil Med* 2023; **188**: e2096-e2101 [PMID: 36705446 DOI: 10.1093/milmed/usad009]

48 **Ishiguro H**, Kodama S, Horikawa C, Fujihara K, Hirose AS, Hirasawa R, Yachi Y, Ohara N, Shimano H, Hanyu O, Sone H. In Search of the Ideal Resistance Training Program to Improve Glycemic Control and its Indication for Patients with Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. *Sports Med* 2016; **46**: 67-77 [PMID: 26604100 DOI: 10.1007/s40279-015-0379-7]

49 **Ambelu T**, Teferi G. The impact of exercise modalities on blood glucose, blood pressure and body composition in patients with type 2 diabetes mellitus. *BMC Sports Sci Med Rehabil* 2023; **15**: 153 [PMID: 37964349 DOI: 10.1186/s13102-023-00762-9]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: office@baishideng.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com