ISSN 2307-8960 (online)

World Journal of *Clinical Cases*

World J Clin Cases 2023 October 26; 11(30): 7261-7507

Published by Baishideng Publishing Group Inc

WJCC

World Journal of Clinical Cases

Contents

Thrice Monthly Volume 11 Number 30 October 26, 2023

World Journal of Clinical Cases

Thrice Monthly Volume 11 Number 30 October 26, 2023

Contents

World Journal of Clinical Cases

Thrice Monthly Volume 11 Number 30 October 26, 2023

Contents

ABOUT COVER

Editorial Board Member of *World Journal of Clinical Cases*, Ravindra Shukla, MBBS, MD, Additional Professor, Department of Endocrinology and Metabolism, All India Institute of Medical Sciences, Jodhpur 342001, Rajasthan, India. ravindrashukla2@rediffmail.com

AIMS AND SCOPE

The primary aim of *World Journal of Clinical Cases* (*WJCC*, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

WJCC mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

INDEXING/ABSTRACTING

The *WJCC* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Journal Citation Reports/Science Edition, Current Contents®/Clinical Medicine, PubMed, PubMed Central, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2023 Edition of Journal Citation Reports® cites the 2022 impact factor (IF) for *WJCC* as 1.1; IF without journal self cites: 1.1; 5-year IF: 1.3; Journal Citation Indicator: 0.26; Ranking: 133 among 167 journals in medicine, general and internal; and Quartile category: Q4.

RESPONSIBLE EDITORS FOR THIS ISSUE

NAME OF JOURNAL
World Journal of Clinical Cases

ISSN
ISSN 2307-8960 (online)

LAUNCH DATE
April 16, 2013

FREQUENCY
Thrice Monthly

PUBLICATION DATE
October 26, 2023

World Journal of Clinical Cases

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

World J Clin Cases 2023 October 26; 11(30): 7309-7317

DOI: 10.12998/wjcc.v11.i30.7309

ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Observational Study

High risk for obstructive sleep apnea and risk of hypertension in military personnel: The CHIEF sleep study

Wei-Nung Liu, Ko-Huan Lin, Kun-Zhe Tsai, Chen-Chih Chu, Yun-Chen Chang, Younghoon Kwon, 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 scientific quality classification

Grade A (Excellent): A
Grade B (Very good): B
Grade C (Good): 0
Grade D (Fair): 0
Grade E (Poor): 0

P-Reviewer: Mahmoud MZ, Saudi Arabia

Received: July 28, 2023
Peer-review started: July 28, 2023
First decision: September 19, 2023
Revised: September 21, 2023
Accepted: September 28, 2023
Article in press: September 28, 2023
Published online: October 26, 2023

Wei-Nung Liu, Chen-Chih Chu, Gen-Min Lin, Department of Medicine, Tri-Service General Hospital, National Defense Medical Center, Taipei 114, 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

Yun-Chen Chang, School of Nursing and Graduate Institute of Nursing, China Medical University, Taichung 406, Taiwan

Younghoon Kwon, Department of Medicine, University of Washington, Seattle, 98104-2499, United States

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

Corresponding author: Gen-Min Lin, FACC, FAHA, MD, PhD, Academic Editor, 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

Epidemiological studies have revealed an association between obstructive sleep apnea (OSA) and hypertension in the general population, while the association in military personnel was rarely investigated.

AIM

To examine the association between high risk for OSA and hypertension by phenotypes in military young adults.

METHODS

A total of 746 military personnel, aged 27.9 years, were included in the cardiorespiratory fitness and health in armed forces (CHIEF)-sleep study in Taiwan in 2020. Antihypertensive medications were not used by the subjects. High risk for OSA was assessed using the Berlin Questionnaire. Hypertension was defined using the 7th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) and the 2017 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines. The cutoff

levels of systolic and diastolic blood pressure (SBP and DBP) for the 2017 ACC/AHA- and JNC 7-based guidelines were 130/140 mmHg and 80/90 mmHg, respectively. Hypertension phenotypes included isolated systolic and diastolic hypertension (ISH, high SBP only and IDH, high DBP only) and combined hypertension (both high SBP and DBP). Multivariable logistic regression analysis with adjustment for demographics, lifestyle and metabolic biomarkers.

RESULTS

The prevalence of high risk for OSA, JNC 7-based hypertension and 2017 ACC/AHA-based hypertension were 8.0%, 5.2% and 22.0%, respectively. Those with a high risk for OSA had a higher probability of JNC 7-based overall and combined hypertension (odds ratios (ORs) and 95% confidence intervals: 2.82 (1.07-7.42) and 7.54 (1.10-51.54), although the probabilities of ISH and IDH were unaffected by a high risk for OSA (ORs: 1.96 and 2.35, respectively, both $P > 0.05$). In contrast, no associations for any hypertension phenotypes were found according to the 2017 ACC/AHA criteria.

CONCLUSION

A high risk for OSA was associated with severe hypertension and combined hypertension among Asian military young adults.

Key Words: Asian young adults; Berlin questionnaire; Hypertension phenotypes; Military; Sleep apnea

Core Tip: This study examined the association between high risk for obstructive sleep apnea (OSA) and hypertension by phenotypes in military young adults. We found that those with a high risk for OSA had a higher probability of JNC-based overall and combined hypertension [ORs: 2.82 (95%CI: 1.07-7.42) and 7.54 (95%CI: 1.10-51.54)], although the probabilities of isolated systolic hypertension and isolated diastolic hypertension were not impacted by a high risk for OSA (ORs: 1.96 and 2.35, respectively, both $P > 0.05$). In contrast, no associations for any hypertension phenotypes were found on the basis of the 2017 American College of Cardiology/American Heart Association criteria. In conclusion, a high risk for OSA was associated with severe hypertension and combined hypertension among Asian military young adults.

Citation: 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(30): 7309-7317
URL: https://www.wjgnet.com/2307-8960/full/v11/i30/7309.htm
DOI: https://dx.doi.org/10.12998/wjcc.v11.i30.7309

INTRODUCTION

Obstructive sleep apnea (OSA) has the potential to engender grave adverse consequences, notably an amplified vulnerability to cardiovascular diseases and neurocognitive morbidities[1,2]. OSA is characterized by recurrent episodes of respiratory airflow cessation related to upper-airway collapse during sleep, leading to decreased oxygen saturation[3]. A recent systematic review noted the dearth of data regarding the prevalence of OSA in the Asian population[4]. Epidemiological surveys have shown a significant association between OSA and hypertension in both general population samples and clinic-based cohorts[1,5-8]. Hypertension represents a prominent risk factor for cardiovascular diseases and all-cause mortality[9]. Reports indicate that the prevalence of hypertension in Asia is comparable to that observed in Western countries; however, there exists a notable disparity in the awareness of hypertension, with significantly lower levels in Asian populations compared to their Western counterparts[10]. There may be more individuals with undiagnosed hypertension in the Asian population with certain sleep-related disorders.

However, insufficient emphasis has been placed on examining the associations between OSA and hypertension in young adults. As the relationship between OSA and hypertension is characterized by its intricate and multifaceted nature, OSA and obesity usually coexist and exhibit overlapping pathophysiological mechanisms[11]. Epidemiological surveys provide evidence supporting the associations between obesity and hypertension, as well as OSA and obesity[3,5,12,13]. To our knowledge, the prevalence of hypertension in young adults is much lower than that in middle-aged and older individuals. Whether obesity is a moderator between OSA and hypertension remains unclear in young adults.

The purpose of this study was to determine the prevalence of high OSA risk and its association of hypertension with various phenotypes in military young personnel who have rarely been investigated before in Taiwan. In addition, the roles of age, central obesity and night sentry duty in modifying the association between OSA and hypertension were examined.

MATERIALS AND METHODS

Study population

In the ancillary Cardiorespiratory Fitness and Health in Armed Forces (CHIEF) sleep study implemented in Taiwan in 2020, a sample of 746 military personnel, with an average age of 27.9 years, was recruited. Significantly, individuals with antihypertensive medication use were intentionally excluded from the study protocol. The assessment of the risk for OSA was undertaken using the well-validated Berlin Questionnaire[14,15]. The study design was approved by the Mennonite Christian Hospital Ethics Committee (No. 16-05-008) in Hualien, Taiwan, and was performed in accordance with the Helsinki Declaration, as revised in 2013. All participants were informed of the nature of the study and gave written informed consent.

Individuals at high risk for OSA

Participants at high risk for OSA in this investigation were defined according to the Berlin Questionnaire[14,15], which consists of three distinct sections. The first section is used to evaluate snoring behavior, the second is used to evaluate fatigue, tiredness, and daytime sleepiness symptoms, and the third is used to investigate the presence of obesity or hypertension. In Sections 1 and 2, a persistent symptom reported more than 3-4 times per week is indicative of high risk for OSA. In Section 3, a historical diagnosis of hypertension or a body mass index (BMI) ≥ 30.0 kg/m^2 is considered as criteria suggestive of high risk for OSA. Individuals are classified as high risk for OSA if they meet the high-risk benchmarks in at least two of the questionnaire's three sections.

Definitions of hypertension and phenotypes

Hypertension was defined based on the diagnostic guidelines included in both the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7)[9] and the recommendations from the American College of Cardiology (ACC) and American Heart Association (AHA) in 2017[16], thereby ensuring a uniform and methodical approach to categorization and subsequent data analysis. In this study, the resting blood pressure (BP) of each participant was measured once over the right upper arm in a sitting position by an automatic device through the oscillometric method (FT201 Parama-Tech Co., Ltd, Fukuoka, Japan)[17-20]. The cutoff values for systolic and diastolic BP for hypertension, as specified by the 2017 ACC/AHA and JNC 7 guidelines, were established at 130/140 mmHg and 80/90 mmHg, respectively. Within the context of these guidelines, hypertension phenotypes were classified as combined hypertension (marked by elevated levels of both SBP and DBP), isolated systolic hypertension (ISH, identified by elevated SBP only), and isolated diastolic hypertension (IDH, identified by elevated DBP only).

Confounding factors for OSA and hypertension

Participants were asked about their smoking and alcohol consumption status (active *vs* former/never)[21,22] and cardiorespiratory fitness (assessed by 3000-m run performance in 2020)[23-25]. Sentry duty at night was evaluated by times per month. Abdominal obesity was defined as a waist circumference ≥ 90 cm for men and ≥ 80 cm for women[26]. Fasting blood samples were obtained to measure metabolic risk factors, *i.e.*, a lipid panel test, fasting glucose and serum uric acid[27-30].

Statistical analysis

Statistical evaluations were executed utilizing SPSS software for Windows (SPSS Inc., Chicago, IL, United States). To compare subjects with high risk for OSA and those without, the chi-square test was used for categorical data, and analysis of variance (ANOVA) was used for continuous data. Multiple logistic regression analysis was used to determine the associations between high risk for OSA and hypertension phenotypes, *i.e.*, combined hypertension, ISH and IDH. Model 1 was the unadjusted model. Model 2 was adjusted for age, sex, smoking, alcohol intake and 3000-m run time. Model 3 was additionally adjusted for total cholesterol, high-density lipoprotein, low-density lipoprotein, triglycerides and uric acid. Model 4 was further adjusted for BMI. Subgroup analysis was performed based on age (≥ 30 years *vs* < 30 years), abdominal obesity status and night sentry status. The covariates in the models were selected due to their potential as risk factors for both hypertension and OSA and a P value < 0.20 between the two groups. A P value of < 0.05 was considered indicative of statistical significance.

RESULTS

Table 1 shows the clinical profiles of participants with high risk for OSA (n = 60, 8.0%) and those without (n = 686, 92%), based on the responses to the Berlin Questionnaire. The mean age of the high-risk OSA group was significantly higher than that of their counterparts (30.45 years *vs* 27.67 years). The high-risk OSA group had higher BMI, waist circumference systolic and diastolic BP levels and ran slower than their counterparts. The prevalence of JNC-7-based hypertension was higher in the high risk for OSA group, whereas no difference between the high risk for OSA group and the counterparts was observed. In addition, the prevalence of all hypertension phenotypes was higher in the high-risk OSA group, while only combined hypertension was higher in the high-risk OSA group. The high-risk OSA group had a lower high-density lipoprotein level and higher serum triglycerides and uric acid levels than their counterparts.

Table 2 demonstrates the results of multivariable logistic regression analyses of high risk of OSA for various hypertension phenotypes according to the JNC 7-based guidelines. In Model 1, the odds ratio (OR) of all hypertension

Table 1 Characteristics of Participants Reporting Berlin Questionnaire

	Low risk for OSA (*n* = 686)	High risk for OSA (*n* = 60)	*P* value
Age, yr	27.67 ± 5.74	30.45 ± 5.86	< 0.001
Male sex, %	601 (87.6)	55 (91.7)	0.35
Tobacco consumption, %	286 (41.7)	32 (53.3)	0.08
Alcohol intake, %	242 (38.0)	27 (45.0)	0.16
Night sentry duty%			
0/mo	373 (54.4)	28 (46.7)	0.26
1/mo	87 (12.7)	6 (10.0)	
≥ 2/mo	226 (32.9)	26 (43.3)	
Time for a 3000-m run, s	900.44 ± 117.15	949.19 ± 255.01	0.008
Body mass index, kg/m^2	24.11 ± 3.65	27.75 ± 4.27	< 0.001
Waist circumference, cm	81.20 ± 9.63	92.04 ± 13.79	< 0.001
Systolic blood pressure, mmHg	116.32 ± 12.17	120.41 ± 16.28	0.01
Diastolic blood pressure, mmHg	68.79 ± 9.01	72.77 ± 12.41	0.002
Hypertension (JNC 7)	29 (4.2)	10 (16.7)	< 0.001
ISH	16 (2.3)	4 (6.7)	< 0.001
IDH	11 (1.6)	3 (5.0)	
CH	2 (0.3)	3 (5.0)	
Hypertension (2017 ACC/AHA)	147 (21.4)	17 (28.3)	0.21
ISH	63 (9.2)	5 (8.3)	0.02
IDH	40 (5.8)	2 (3.3)	
CH	44 (6.4)	10 (16.7)	
Blood test			
Total cholesterol, mg/dL	170.51 ± 31.56	178.15 ± 31.02	0.07
Low-density lipoprotein, mg/dL	103.97 ± 28.64	109.93 ± 26.58	0.12
High-density lipoprotein, mg/dL	50.91 ± 10.80	46.93 ± 9.90	0.006
Serum triglycerides, mg/dL	98.65 ± 71.06	143.65 ± 122.28	< 0.001
Fasting glucose, mg/dL	94.90 ± 10.00	94.75 ± 10.12	0.91
Serum uric acid, mg/dL	6.42 ± 1.42	6.95 ± 1.41	0.006

ACC: American College of Cardiology; AHA: American Heart Association; CH: combined hypertension; IDH: Isolated diastolic hypertension; ISH: Isolated systolic hypertension; JNC: Joint National Committee hypertension guideline; OSA: Obstructive sleep apnea.

phenotypes was greater than 2.75, in which only overall (ISH, IDH and combined) and combined hypertension were significantly associated with a high risk for OSA. The associations of overall and combined hypertension with high risk for OSA remained significant with adjustments for the potential covariates in Models 2-4 [ORs: 2.82 (95% confidence interval (CI): 1.07-7.46) and 7.54 (95%CI: 1.10-51.54), respectively, in Model 4].

Table 3 shows the results of multivariable logistic regression analyses of high risk for OSA for various hypertension phenotypes using the 2017 ACC/AHA-based guidelines. Combined hypertension was the only phenotype significantly associated with a high risk for OSA [OR: 2.53 (95%CI: 1.10-5.79)], whereas there were no associations for ISH, IDH and overall hypertension (ORs: 1.06, 0.67 and 1.38, respectively). However, the associations for all hypertension phenotypes were not significant in Models 2-4.

Table 4 reveals the results of the associations of JNC 7- and 2017 ACC/AHA-based hypertension with high risk for OSA in subgroup analyses based on age, abdominal obesity and night sentry duty status. In the subgroup analysis based on age, the association of high risk for OSA with JNC 7-based hypertension was significant in participants aged ≥ 30 years [OR: 4.55 (95%CI: 1.50-13.78)] but not significant in those aged < 30 years (OR: 2.07). In the subgroup analysis by abdominal obesity status, the association between high risk for OSA and JNC 7-based hypertension was significant in those without abdominal obesity [OR: 5.83 (95%CI: 1.42-23.95)] but not significant in those with abdominal obesity (OR:

Table 2 Multivariable Logistic Regressions of High Risk for Obstructive Sleep Apnea with 7th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) Based Hypertension Phenotypes

	JNC 7 based hypertension			JNC 7 based hypertension phenotypes								
				ISH			IDH			CH		
	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value
Model 1	4.28	1.82-10.08	0.001	2.75	0.76-9.93	0.12	3.21	0.66-15.57	0.14	19.27	3.14-118.29	0.001
Model 2	3.95	1.61-9.67	0.003	2.66	0.71-9.92	0.14	3.05	0.59-15.89	0.18	13.75	2.14-88.50	0.006
Model 3	3.63	1.44-9.16	0.006	2.51	0.66-9.54	0.17	2.96	0.55-15.92	0.2	11.5	1.67-79.03	0.01
Model 4	2.82	1.07-7.46	0.03	1.96	0.49-7.83	0.33	2.35	0.39-14.33	0.35	7.54	1.10-51.54	0.03

Data are presented as odds ratio (OR) and 95% confidence intervals (CI). Model 1: Unadjusted. Model 2: Age, sex, alcohol intake, cigarette smoking and time for a 3000-m run. Model 3: Model 2 + total cholesterol, high-density lipoprotein, low-density lipoprotein, serum triglycerides and serum uric acid. Model 4: Model 3 + body mass index. CH: Combined hypertension; IDH: Isolated diastolic hypertension; ISH: Isolated systolic hypertension; JNC: Joint National Committee hypertension guideline.

Table 3 Multivariable Logistic Regressions of High Risk for Obstructive Sleep Apnea with 2017 American College of Cardiology/American Heart Association Based Hypertension Phenotypes

	2017 ACC/AHA based hypertension			2017 ACC/AHA based hypertension phenotypes								
				ISH			IDH			CH		
	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value	OR	95%CI	*P* value
Model 1	1.38	0.74-2.58	0.31	1.06	0.40-2.81	0.90	0.67	0.15-2.87	0.58	2.53	1.10-5.79	0.02
Model 2	1.08	0.56-2.10	0.81	0.97	0.36-2.61	0.95	0.35	0.06-2.00	0.23	1.95	0.81-4.68	0.13
Model 3	0.94	0.47-1.87	0.85	0.85	0.31-2.34	0.75	0.30	0.05-1.72	0.17	1.69	0.68-4.23	0.26
Model 4	0.77	0.38-1.58	0.48	0.66	0.24-1.86	0.43	0.32	0.06-1.74	0.18	1.38	0.53-3.62	0.51

Data are presented as odds ratio (OR) and 95% confidence intervals (CI). Model 1: Unadjusted. Model 2: Age, sex, alcohol intake, cigarette smoking and time for a 3000-m run. Model 3: Model 2 + total cholesterol, high-density lipoprotein, low-density lipoprotein, serum triglycerides and serum uric acid. Model 4: Model 3 + body mass index. ACC: American College of Cardiology; AHA: American Heart Association; CH: Combined hypertension; IDH: Isolated diastolic hypertension; ISH: Isolated systolic hypertension.

2.01). In the subgroup analysis by the presence of night sentry duty, the association between high risk for OSA and JNC 7-based hypertension was significant in those free of night sentry duty [OR: 5.28 (95%CI: 1.35-20.71)] but not significant in those having at least one occurrence of night sentry duty per month (OR: 2.73). Notably, the association between high risk for OSA and 2017 ACC/AHA-based hypertension was not significant in any subgroup analyses based on age, abdominal obesity status and night sentry duty status.

DISCUSSION

The principal findings in this study were that young individuals with a high risk for OSA, as determined by the Berlin Questionnaire, had a higher probability of having hypertension based on the JNC 7 guidelines or stage-2 hypertension based on the 2017 ACC/AHA guidelines but not mild hypertension according to the 2017 ACC/AHA guidelines. In addition, we found that combined hypertension was the most commonly encountered hypertension phenotype associated with a high risk for OSA among young military adults.

In this study, young individuals identified as high risk for OSA exhibited a higher prevalence of traditional cardiovascular risk factors in addition to elevated BP, such as abdominal obesity and dyslipidemia[17-19]. The clinical characteristics of our study population were in line with the general consensus in the literature regarding the comorbidities of OSA and cardiovascular diseases among adults, regardless of age[31]. The Berlin Questionnaire has been commonly used to define young adults at high risk for OSA and has been validated in many studies (31, 32). The validity has also been investigated in a Korean study of young military subjects by Lee *et al*[31] that included a similar age group cohort. In that Korean study[31], the prevalence of high OSA risk (8.1%) was very close to our finding (8.0%), and Lee *et al* [31] found that in a Korean military sample, 90% of these young subjects with a high risk for OSA by the Berlin questionnaire had an apnea-hypopnea index ≥ 5 events/hour. Similarly, the prevalence of high OSA risk in a sample of

Table 4 Subgroup Analyses for the Association of High Risk for Obstructive Sleep Apnea with Hypertension Phenotypes According to Age and Abdominal Obesity and Night Sentry Duty Status

Variables	JNC 7 based hypertension			2017 ACC/AHA based hypertension		
	OR	95%CI	*P* value	OR	95%CI	*P* value
Age						
< 30 yr	2.07	0.35-12.07	0.42	1.34	0.49-3.66	0.56
≥ 30 yr	4.55	1.50-13.78	0.007	0.83	0.34-2.02	0.67
Abdominal obesity (based on WS)						
< 90 cm in men, < 80 cm in women	5.83	1.42-23.95	0.01	1.58	0.59-4.23	0.36
≥ 90 cm in men, ≥ 80 cm in women	2.01	0.64-6.26	0.23	0.55	0.22-1.38	0.2
Night sentry duty						
0/mo	5.28	1.35-20.71	0.01	0.87	0.31-2.41	0.78
≥ 1/mo	2.73	0.62-11.99	0.18	1.29	0.49-3.43	0.6

Data are presented as odds ratio (OR) and 95% confidence intervals (CI). Multivariable logistic regression was used to determine the association with adjustment for Age, sex, alcohol intake, cigarette smoking and time for a 3000-m run, total cholesterol, high-density lipoprotein, low-density lipoprotein, serum triglycerides, serum uric acid and body mass index. ACC: American College of Cardiology; AHA: American Heart Association; WS: Waist circumference; JNC: Joint National Committee hypertension guidelines.

young Thai adults was 6.3%[32], which was also close to our finding (8.0%).

The association between high risk for OSA and JNC 7-based hypertension, also corresponding to stage-2 hypertension on the basis of the 2017 ACC/AHA guidelines, in young adults has been found consistently in the Thailand study mentioned above[32]. The results of the Thailand study[32] were also consistent with our study in some aspects, including that the association strength of high risk for OSA was stronger for JNC 7-based hypertension than an elevated BP level, defined as systolic BP ≥120 mmHg or diastolic BP ≥ 80 mmHg, with adjustments for demographic and lifestyle factors (ORs: 2.55 and 2.38, respectively). In addition, the strength of the association of high risk for OSA was greater for ISH than IDH (ORs: 3.03 and 2.78, respectively). In contrast, the association of high risk for OSA with combined hypertension as the lowest among the phenotypes in the Thailand study[32] was inconsistent with our study findings. The reason for the differences in the association between high risk for OSA and various hypertension phenotypes was unclear but is possibly because our study subjects were recruited from a specific sample of military personnel who were at a greater stress and workload than the general population. Mechanisms for more severe hypertension and uncontrolled BP levels have been postulated by activation of the neurohormonal system and increased psychological stress, which are related to intermittent nocturnal hypoxemia[33,34].

In previous studies, obese and elderly individuals with OSA were found to be at higher risk of hypertension[32,35]. Obesity has been recognized as a crucial risk factor for OSA, possibly due to obesity related to structural changes, *e.g.*, long uvula, low lying palate and tongue indentation in a supine position during sleep[31]. In the general population of young adults[32], obesity was found to be a mediator between a high risk for OSA and hypertension. However, our study showed inconsistent results that military subjects with younger ages and those without abdominal obesity had a greater strength of the associations compared to their older and obese counterparts, despite both having a nonsignificant p value for interaction (data not shown). The inconsistent findings in our study may be reasoned by the possibility of the existence of substantial confounders, *e.g.*, night sentry duty in military subjects, which may cause sleep disturbance and result in an increased risk of hypertension. In addition, in Asian adults, OSA is not uncommon in those without obesity who may have a relatively flat face and oral cavity anatomical adaptations to long-term supine sleep since childhood[36], possibly reducing the importance of obesity in the association between a high risk for OSA and hypertension.

In this study, there were some limitations, *e.g.*, the cross-sectional nature, which precludes establishing causality, and the self-report questionnaires, which may be subject to bias. Additionally, our sample was restricted to military subjects who may have regular on-demand work at night, which may confound sleep quality, limiting the generalizability of our study findings. Finally, an objective assessment of OSA, such as polysomnography, was lacking, and some subjects may have been misclassified, leading to bias. Polysomnography should be used to define OSA for its relationship with hypertension risk in future studies. In contrast, our study had some strengths. Our study population was obtained from the military and had similar living circumstances, *e.g.*, diet and training status, possibly minimizing the naïve bias. Second, since our health examinations were comprehensive, the adjustments in the models were believed to be accurate.

CONCLUSION

Our findings suggest that in Asian military young adults, high risk for OSA, as assessed by the Berlin Questionnaire, accounted for 8.0% of the population and was associated with a higher probability of uncontrolled BP levels, defined by the JNC 7 criterion. Notably, the association was not related to obesity or older age. As the specific population of Asian military subjects we studied, how night activity confounded the association in the military requires further study.

ARTICLE HIGHLIGHTS

Research background

Previous studies have revealed an association between obstructive sleep apnea (OSA) and hypertension in the general population, whereas the association in military personnel was rarely investigated.

Research motivation

Military personnel have some risk factors for both OSA and hypertension, *e.g.* night duty which are rarely seen in the general population.

Research objectives

To investigate the association between high risk for OSA and hypertension by phenotypes in military young adults.

Research methods

A total of 746 military personnel, aged 27.9 years, were included in the cardiorespiratory fitness and health in armed forces (CHIEF)-sleep study in Taiwan in 2020. Antihypertensive medications were not used by the subjects. High risk for OSA was assessed using the Berlin Questionnaire. Hypertension was defined using the 7th Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) and the 2017 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines. The cutoff levels of systolic and diastolic blood pressure (SBP and DBP) for the 2017 ACC/AHA- and JNC 7-based guidelines were 130/140 mmHg and 80/90 mmHg, respectively. Hypertension phenotypes included isolated systolic and diastolic hypertension (ISH, high SBP only and IDH, high DBP only) and combined hypertension (both high SBP and DBP). Multivariable logistic regression analysis with adjustment for demographics, lifestyle and metabolic biomarkers.

Research results

The prevalence of high risk for OSA, JNC 7-based hypertension and 2017 ACC/AHA-based hypertension were 8.0%, 5.2% and 22.0%, respectively. Those with a high risk for OSA had a higher probability of JNC 7-based overall and combined hypertension (odds ratios (ORs) and 95% confidence intervals: 2.82 (1.07, 7.42) and 7.54 (1.10, 51.54), although the probabilities of ISH and IDH were unaffected by a high risk for OSA (ORs: 1.96 and 2.35, respectively, both $P > 0.05$). In contrast, no associations for any hypertension phenotypes were found according to the 2017 ACC/AHA criteria.

Research conclusions

High risk for OSA, as assessed by the Berlin Questionnaire, accounted for 8.0 % of the military population and was associated with a higher probability of uncontrolled BP levels, defined by the JNC 7 criterion. Notably, the association was not related to obesity or older age.

Research perspectives

For military personnel, polysomnography should be used to define OSA for its relationship with hypertension risk in future studies. In addition, night activity confounded the association in the military personnel requires further study.

FOOTNOTES

Author contributions: Liu WN wrote the article; Lin KH collected the data; Lin GM and Lin KH contributed to conception and design of the CHIEF sleep study, and acquired and interpreted the data; Tsai KZ analyzed the data; Chu CC and Chang YC collected and reviewed the data; Younghoon kwon edited and made critical revisions related to important intellectual content of the manuscript; All authors provided approval of the final version of the article to be published.

Supported by the Medical Affairs Bureau Ministry of National Defense, No. MND-MAB-D-112182; Hualien Armed Forces General Hospital, No. HAFGH-D-112004.

Institutional review board statement: This study was reviewed and approved by the Institutional Review Board of the Mennonite Christian Hospital (No. 16-05-008) in Hualien City, Taiwan.

Informed consent statement: The written informed consent was obtained from all participants.

Conflict-of-interest statement: All 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/Territory of origin: Taiwan

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

S-Editor: Liu JH
L-Editor: A
P-Editor: Yuan YY

REFERENCES

1 **Cowie MR**, Linz D, Redline S, Somers VK, Simonds AK. Sleep Disordered Breathing and Cardiovascular Disease: JACC State-of-the-Art Review. *J Am Coll Cardiol* 2021; **78**: 608-624 [PMID: 34353537 DOI: 10.1016/j.jacc.2021.05.048]
2 **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]
3 **Álvarez D**, Gutiérrez-Tobal GC, Vaquerizo-Villar F, Moreno F, Del Campo F, Hornero R. Oximetry Indices in the Management of Sleep Apnea: From Overnight Minimum Saturation to the Novel Hypoxemia Measures. *Adv Exp Med Biol* 2022; **1384**: 219-239 [PMID: 36217087 DOI: 10.1007/978-3-031-06413-5_13]
4 **Mirrakhimov AE**, Sooronbaev T, Mirrakhimov EM. Prevalence of obstructive sleep apnea in Asian adults: a systematic review of the literature. *BMC Pulm Med* 2013; **13**: 10 [PMID: 23433391 DOI: 10.1186/1471-2466-13-10]
5 **Logan JG**, Kang H, Lobo JM, Sohn MW, Lin GM, Lima JAC, Punjabi NM, Redline S, Kwon Y. Actigraphy-based sleep characteristics and aortic stiffness: the Multi-Ethnic Study of Atherosclerosis. *J Am Soc Hypertens* 2018; **12**: 841-849 [PMID: 30396853 DOI: 10.1016/j.jash.2018.09.008]
6 **Gus M**, Gonçalves SC, Martinez D, de Abreu Silva EO, Moreira LB, Fuchs SC, Fuchs FD. Risk for Obstructive Sleep Apnea by Berlin Questionnaire, but not daytime sleepiness, is associated with resistant hypertension: a case-control study. *Am J Hypertens* 2008; **21**: 832-835 [PMID: 18451807 DOI: 10.1038/ajh.2008.184]
7 **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]
8 **Salman LA**, Shulman R, Cohen JB. Obstructive Sleep Apnea, Hypertension, and Cardiovascular Risk: Epidemiology, Pathophysiology, and Management. *Curr Cardiol Rep* 2020; **22**: 6 [PMID: 31955254 DOI: 10.1007/s11886-020-1257-y]
9 **Chobanian AV**, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ; National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; National High Blood Pressure Education Program Coordinating Committee. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA* 2003; **289**: 2560-2572 [PMID: 12748199 DOI: 10.1161/01.HYP.0000107251.49515.c2]
10 **Kim JS**, Song WH, Shin C, Park CG, Seo HS, Shim WJ, Oh DJ, Ryu SH, Rho YM. The prevalence and awareness of hypertension and the relationship between hypertension and snoring in the Korean population. *Korean J Intern Med* 2001; **16**: 62-68 [PMID: 11590903 DOI: 10.3904/kjim.2001.16.2.62]
11 **Khan MA**, Mathur K, Barraza G, Sin S, Yang CJ, Arens R, Sutton N, Mahgerefteh J. The relationship of hypertension with obesity and obstructive sleep apnea in adolescents. *Pediatr Pulmonol* 2020; **55**: 1020-1027 [PMID: 32068974 DOI: 10.1002/ppul.24693]
12 **Stafford PL**, Harmon EK, Patel P, Walker M, Lin GM, Park SJ, Chatterjee NA, Mehta NK, Mazimba S, Bilchick K, Kwon Y. The Influence of Obesity on the Association of Obstructive Sleep Apnea and Atrial Fibrillation. *Sleep Med Res* 2021; **12**: 50-56 [PMID: 34497733 DOI: 10.17241/smr.2021.00857]
13 **Ostchega Y**, Hughes JP, Terry A, Fakhouri TH, Miller I. Abdominal obesity, body mass index, and hypertension in US adults: NHANES 2007-2010. *Am J Hypertens* 2012; **25**: 1271-1278 [PMID: 22895451 DOI: 10.1038/ajh.2012.120]
14 **Hiestand DM**, Britz P, Goldman M, Phillips B. Prevalence of symptoms and risk of sleep apnea in the US population: Results from the national sleep foundation sleep in America 2005 poll. *Chest* 2006; **130**: 780-786 [PMID: 16963675 DOI: 10.1378/chest.130.3.780]
15 **Netzer NC**, Stoohs RA, Netzer CM, Clark K, Strohl KP. Using the Berlin Questionnaire to identify patients at risk for the sleep apnea syndrome. *Ann Intern Med* 1999; **131**: 485-491 [PMID: 10507956 DOI: 10.7326/0003-4819-131-7-199910050-00002]
16 **Muntner P**, Carey RM, Gidding S, Jones DW, Taler SJ, Wright JT Jr, Whelton PK. Potential US Population Impact of the 2017 ACC/AHA

High Blood Pressure Guideline. *Circulation* 2018; **137**: 109-118 [PMID: 29133599 DOI: 10.1161/CIRCULATIONAHA.117.032582]

17 **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]

18 **Liu PY**, Lin YK, Chen KW, Tsai KZ, Lin YP, Takimoto E, Lin GM. Association of Liver Transaminase Levels and Long-Term Blood Pressure Variability in Military Young Males: The CHIEF Study. *Int J Environ Res Public Health* 2020; **17** [PMID: 32825751 DOI: 10.3390/ijerph17176094]

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 **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]

21 **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]

22 **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]

23 **Lin GM**, Liu PY, Tsai KZ, Lin YK, Huang WC, Lavie CJ. Cardiorespiratory Fitness and Carotid Intima-Media Thickness in Physically Active Young Adults: CHIEF Atherosclerosis Study. *J Clin Med* 2022; **11** [PMID: 35806938 DOI: 10.3390/jcm11133653]

24 **Lin KH**, Chen YJ, Yang SN, Liu MW, Kao CC, Nagamine M, Vermetten E, Lin GM. Association of Psychological Stress with Physical Fitness in a Military Cohort: The CHIEF Study. *Mil Med* 2020; **185**: e1240-e1246 [PMID: 32239167 DOI: 10.1093/milmed/usz469]

25 **Lai SW**, Tsai KZ, Lin YP, Liu PY, Lin YK, Chang PY, Dai MS, Chao TY, Han CL, Lin GM. Association of red blood cell size and physical fitness in a military male cohort: The CHIEF study. *Scand J Med Sci Sports* 2021; **31**: 295-302 [PMID: 32979255 DOI: 10.1111/sms.13836]

26 **Ruff DW**, Dhingra DM, Thompson K, Marin JA, Ooi AT. High-Throughput Multimodal Single-Cell Targeted DNA and Surface Protein Analysis Using the Mission Bio Tapestri Platform. *Methods Mol Biol* 2022; **2386**: 171-188 [PMID: 34766272 DOI: 10.1007/978-1-0716-1771-7_12]

27 **Tsai KZ**, Liu PY, Huang WC, Lima JAC, Lavie CJ, Lin GM. Sex-specific cardiometabolic risk markers of left ventricular mass in physically active young adults: the CHIEF heart study. *Sci Rep* 2022; **12**: 11536 [PMID: 35798830 DOI: 10.1038/s41598-022-15818-y]

28 **Wang SH**, Chung PS, Lin YP, Tsai KZ, Lin SC, Fan CH, Lin YK, Lin GM. Metabolically healthy obesity and physical fitness in military males in the CHIEF study. *Sci Rep* 2021; **11**: 9088 [PMID: 33907258 DOI: 10.1038/s41598-021-88728-0]

29 **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]

30 **Lin YK**, Lin YP, Lee JT, Lin CS, Wu TJ, Tsai KZ, Su FY, Kwon Y, Hoshide S, Lin GM. Sex-specific association of hyperuricemia with cardiometabolic abnormalities in a military cohort: The CHIEF study. *Medicine (Baltimore)* 2020; **99**: e19535 [PMID: 32195957 DOI: 10.1097/MD.0000000000019535]

31 **Lee YC**, Eun YG, Shin SY, Kim SW. Prevalence of snoring and high risk of obstructive sleep apnea syndrome in young male soldiers in Korea. *J Korean Med Sci* 2013; **28**: 1373-1377 [PMID: 24015045 DOI: 10.3346/jkms.2013.28.9.1373]

32 **Pensuksan WC**, Chen X, Lohsoonthorn V, Lertmaharit S, Gelaye B, Williams MA. High risk for obstructive sleep apnea in relation to hypertension among southeast Asian young adults: role of obesity as an effect modifier. *Am J Hypertens* 2014; **27**: 229-236 [PMID: 24132995 DOI: 10.1093/ajh/hpt194]

33 **Briançon-Marjollet A**, Weiszenstein M, Henri M, Thomas A, Godin-Ribuot D, Polak J. The impact of sleep disorders on glucose metabolism: endocrine and molecular mechanisms. *Diabetol Metab Syndr* 2015; **7**: 25 [PMID: 25834642 DOI: 10.1186/s13098-015-0018-3]

34 **Phillips CL**, O'Driscoll DM. Hypertension and obstructive sleep apnea. *Nat Sci Sleep* 2013; **5**: 43-52 [PMID: 23750107 DOI: 10.2147/NSS.S34841]

35 **Peppard PE**, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol* 2013; **177**: 1006-1014 [PMID: 23589584 DOI: 10.1093/aje/kws342]

36 **Quo SD**, Pliska BT, Huynh N. Oropharyngeal growth and skeletal malformations. Principles and Practice of Sleep Medicine. Sixth Edit. *Elsevier* 2017; 1401-1422 [DOI: 10.1016/B978-0-323-24288-2.00143-4]

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