ELMER PRESS

Check for updates

Original Article

J Clin Med Res. 2024;16(12):600-607

Simple Subjective Sleep Quality and Blood Pressure in Individuals With Optimal Sleep Duration: A Cross-Sectional Study

Kenshu Taira[a], Yumeno Fukumine[a], Koshi Nakamura[a, b]

Abstract

Background: An individual's simple subjective feeling of having poor sleep quality usually occurs in combination with short sleep duration. Previous studies have mainly investigated the association between simple subjective sleep quality and blood pressure in a general population without considering the complicated issue regarding poor sleep quality and short sleep duration. The aim of this study was therefore to investigate whether poor sleep quality was associated with increased blood pressure in individuals with optimal sleep duration.

Methods: A cross-sectional study was conducted on 169 residents aged ≥ 18 years who lived in a remote island of Okinawa, Japan. The participants had a sleep duration of 6 - 7.9 h/day on weekdays and were not taking either sleep medication or antihypertensive medication. Analysis of covariance was used to compare systolic and diastolic blood pressures in the participants grouped according to simple subjective sleep quality.

Results: Of the 169 participants, 51 (30.2%) reported that their sleep quality was poor. After adjustment for age, sex, and other potential confounders including sleep duration within optimal levels, the participants aged ≤ 49 years had mean (95% confidence interval) systolic and diastolic blood pressures (mm Hg) of 121.0 (114.7 - 127.3) and 68.7 (63.8 - 73.6) in the good sleep quality group, and 127.8 (120.7 - 134.9) and 71.8 (66.2 - 77.3) in the poor sleep quality group (P = 0.01 and P = 0.14, respectively). However, in those aged ≥ 50 years, the corresponding means were 130.6 (121.3 - 139.8) and 79.1 (73.5 - 84.7) in the good-quality group and 126.9 (114.6 - 139.2) and 78.0 (70.5 - 85.4) in the poor-quality group (P = 0.43 and P = 0.68, respectively). There was a statistically significant interaction between simple subjective sleep quality and age for systolic blood pressure (P value for interaction = 0.04).

Conclusions: This study showed that an individual's simple subjective feeling of poor sleep quality was associated with increased systolic blood pressure in participants aged ≤ 49 years with optimal sleep duration. These findings highlight the importance of easily assessing simple subjective sleep quality in clinical settings even in individuals with optimal sleep duration, in order to prevent and manage hypertension.

Keywords: Blood pressure; Hypertension; Optimal sleep duration; Sleep quality

Manuscript submitted November 7, 2024, accepted December 4, 2024
Published online December 20, 2024

[a]Department of Public Health and Epidemiology, Graduate School of Medicine, University of the Ryukyus, Nishihara, Okinawa 903-0215, Japan
[b]Corresponding Author: Koshi Nakamura, Department of Public Health and Epidemiology, Graduate School of Medicine, University of the Ryukyus, Nishihara, Okinawa 903-0215, Japan. Email: knakamur@med.u-ryukyu.ac.jp

doi: https://doi.org/10.14740/jocmr6136

Introduction

Hypertension is a major risk factor for cardiovascular disease including coronary heart disease and stroke [1-3], and due to its high prevalence is a burden of disease worldwide [3-5]. Many epidemiological studies have identified lifestyle factors that increase blood pressure, including excessive alcohol and salt intake, obesity as a result of overeating and/or physical inactivity, and a lack of vegetable intake [5, 6]. Therefore, modification of these lifestyle factors is recommended for prevention and management of hypertension [5, 6]. In addition to these traditional major risk factors for hypertension, short sleep duration and complaints of sleep quality are also associated with increased blood pressure [7, 8].

Detailed sleep quality is quantified comprehensively from perspectives of various complaints [9], whereas the simplest measure of sleep quality can be assessed easily based only on an individual's subjective feelings [10, 11]. A simple subjective complaint regarding sleep may occur usually in combination with short sleep duration. Intended short sleep duration due to going to bed late may result in poor sleep quality, whereas insomnia may lead to both short sleep duration and poor sleep quality. In this regard, previous studies have mainly investigated the association between simple subjective sleep quality and blood pressure in a general population without considering the complicated issue regarding poor sleep quality and short sleep duration [12-14]. It therefore remains unclear whether poor sleep quality - i.e., simple subjective feelings of reduced restfulness and satisfaction with sleep [15] - is associated with increased blood pressure in individuals with optimal sleep duration. The present study aimed to investigate this possibility using cross-sectional data collected from residents in a community in a remote island in Japan.

Materials and Methods

Design and population of the study

A cross-sectional study was conducted as part of a community-based study carried out in Yonaguni Island (Yonaguni town), Okinawa prefecture, Japan, which involved 522 participants aged ≥ 18 years [16]. The target island is the Western-most, small, remote island in Okinawa prefecture, Japan, with an area of 29 km^2. The island is over 500 km from the main island of Okinawa and over 2,000 km from Tokyo, the capital of Japan. The major industries of the island community are fishing, farming, and tourism.

Of the 1,328 individuals aged ≥ 18 years who registered their residency as Yonaguni town, 585 underwent an annual health check-up in June 2022, which the Yonaguni municipal government had organized for all residents aged ≥ 18 years other than those working for one special institution. Of the 585 health check-up examinees, 522 (241 males and 281 females) participated in the Yonaguni Island study that involved completing two self-administered questionnaires. In short, each participant completed our questionnaire in addition to the Yonaguni dietary survey questionnaire that the Yonaguni municipal government had originally included in the health check-up. Each participant then allowed us to combine our questionnaire data with the data from the Yonaguni dietary survey, using the date and receipt number of the health check-up. Since the residence registration system also included individuals who had not lived permanently on the island due to personal issues, we were unable to determine the true response rate.

The study protocol was approved by the Institutional Review Committee for Ethical Issues of University of the Ryukyus (22-1935-01-00-00). The study was conducted in compliance with the ethical standards of the responsible institution on human subjects as well as the Helsinki Declaration. After explanation of the study requirements, each participant provided their written, informed consent by placing a check mark on the participation agreement form.

Of the 522 participants, 353 were deemed ineligible for inclusion in the study for the following reasons: sleeping for < 6 h/day or ≥ 8 h/day on weekdays, considered as short or long sleep duration, respectively [17, 18] (n = 260), taking sleep medications (n = 23), night-shift workers (n = 10), taking antihypertensive medications (n = 48), missing data on simple subjective sleep quality (n = 3), or characteristics other than simple subjective sleep quality, sleep duration, and blood pressure (n = 9). The remaining 169 participants (78 males and 91 females), who had a sleep duration of 6 - 7.9 h/day on weekdays and were not taking either sleep or antihypertensive medications, were included in the final analyses.

Data collection

Simple subjective sleep quality was reported based on the following question extracted from the Pittsburgh Sleep Quality Index (PSQI) [9], which was available in Japanese [19]: "During the past month, how would you rate your sleep quality overall?" The participants were required to select one of the four following responses that most closely represented their experience: "very good", "fairly good", "fairly bad", or "very bad". Poor simple subjective sleep quality was defined as "fairly bad" or "very bad" [20, 21]. The parameter of simple subjective sleep quality used in our study was the most influential component of the seven components making up the PSQI global score [10, 11] and is therefore reliable for the assessment of simple subjective sleep quality. Sleep duration on weekdays was assessed by the responses to the following two questions: "What time do you fall asleep on weekdays?" and "What time do you wake up on weekdays?" Optimal sleep duration on a weekday was defined as sleeping for 6 - 7.9 h/day [17, 18]. This assessment and definition were based on the desirable lifestyle that a sufficient duration of sleep should be achieved on a daily basis, rather than compensating on weekends or holidays for any lack of sleep during the weekdays (i.e., "weekend catch-up sleep") [22].

Well-trained nurses measured the body height and weight and blood pressure of each participant at public community centers from 8:00 am to 4:00 pm except for 0:00 pm - 1:00 pm. The blood pressure measurements were conducted using an automated sphygmomanometer (SC-1800; FUKUDA COLIN Co., Ltd., Tokyo, Japan), which was positioned on the right arm of the participant. The measurements were taken after the participants had rested for a few minutes in the seated position. A single blood pressure measurement was recorded directly in cases with a systolic blood pressure < 130 mm Hg and diastolic blood pressure < 85 mm Hg. Otherwise, the blood pressures were measured twice, and the mean of the two measurements was recorded for analysis. Each participant reported his/her body height and weight, and blood pressure measured during the health check-up by filling out the questionnaire. The body mass index was calculated as weight (kg)/height squared (m^2).

Other data collected in the self-administered questionnaires included age, alcohol drinking habit, smoking habit, behavior for lowering salt intake, and medical history. Alcohol drinking habits were reported as either never drank, former drinker, or current drinker, while smoking habits were reported as either never smoked, former smoker, or current smoker. Behavior for lowering salt intake was reported based on the responses to the following question: "Do you behave to lower salt intake?" Participants were required to select one of the five following responses that most closely represented their behavior for lowering salt intake: "always do", "sometimes do", "will do in the near future", "difficult to do despite willingness", or "never do". Lowering salt intake was defined as "always do" or "sometimes do," while not-lowering salt intake was defined as the remaining three responses [16]. The people in Okinawa prefecture, which includes the target area, have the lowest salt intake (mean 9.1 g/day in males and 8.0 g/day in females) among all the prefectures in Japan (mean 10.8 g/day in males and 9.2 g/day in females) [23].

Statistical analysis

Initially, we used either the unpaired *t*-test or Chi-square test to compare the characteristics of the participants grouped according to their simple subjective sleep quality (i.e., good or poor). We next compared systolic and diastolic blood pressures in the two sleep quality groups using the unpaired *t*-test. Analysis of covariance was then used to compare systolic and diastolic blood pressures in each group following adjustment for potential confounding factors and to calculate the least square mean. The following covariates were included step by step as potential confounding factors in the models: age (year, as a continuous variable), sex (male or female) (model 1); alcohol drinking habit (current drinker or not), smoking habit (current smoker or not), behavior for lowering salt intake (currently do or not), body mass index (kg/m^2, as a continuous variable) (model 2); and sleep duration (h/day, as a continuous variable) (model 3). The analyses were then repeated after the participants had been stratified according to age (≤ 49 or ≥ 50 years). The significance of the interaction between simple subjective sleep quality and age on blood pressure was assessed using an interaction term for the categorical variables in the multivariate-adjusted model. Finally, the analyses were repeated after the participants had been stratified according to age (≤ 39, 40 - 59, or ≥ 60 years).

The analyses were performed using Stata version 17 (StataCorp LP, College Station, TX, USA). All the probability values were two-tailed, and the significance level was set at $P < 0.05$.

Results

Characteristics of the study participants

Table 1 summarizes the characteristics (means or proportions) of the total participants, grouped according to simple subjective sleep quality. The mean (standard deviation) for age and sleep duration on weekdays was 48.8 (15.0) years and 6.8 (0.5) h/day, respectively. Females accounted for 53.9% of the total participants. The mean (standard deviation) was 125.7 (17.2) mm Hg for systolic blood pressure and 74.7 (11.3) mm Hg for diastolic blood pressure. Of the 169 participants, 51 (30.2%) reported that their simple subjective sleep quality was poor. There was no statistically significant difference in any characteristic between the two sleep quality groups. However, compared to the participants with good sleep quality, those with poor sleep quality tended to have a higher proportion of current alcohol drinking and not-lowering their salt intake, although these differences were not statistically significant.

The prevalence of the majority of characteristics was similar for the ≤ 49 years and ≥ 50 years strata, although the prevalence of not-lowering their salt intake was higher in the ≤ 49 years stratum compared to that of the ≥ 50 years stratum (52.7% vs. 23.7%; P < 0.001 (not shown in Table 1)). For the ≤ 49 years stratum, the prevalence of characteristics was broadly similar in the two sleep quality groups. For the ≥ 50 years stratum, only the prevalence of current alcohol drinking tended to be higher in participants with poor sleep quality compared to those with good sleep quality, with this difference not being statistically significant (52.4% vs. 30.9%; P = 0.08) (Table 1).

Simple subjective sleep quality and blood pressure

Table 2 shows the crude and adjusted means (95% confidence intervals) of systolic and diastolic blood pressures in participants grouped according to subjective sleep quality. In the total participants, the poor sleep quality group tended to have a marginally higher mean systolic blood pressure, compared to that measured in the good sleep quality group, although this difference was not statistically significant (128.5 (121.9 - 135.0) mm Hg vs. 126.2 (120.7 - 131.7) mm Hg; P = 0.36). However, mean diastolic blood pressure was similar in the poor and good sleep quality groups (74.2 (69.9 - 78.6) mm Hg and 73.5 (69.9 - 77.2) mm Hg; P = 0.69).

When the participants were stratified by age (≤ 49 or ≥ 50 years), the patterns for blood pressure in the two sleep quality groups were different. In participants aged ≤ 49 years, the poor sleep quality group had a significantly higher mean systolic blood pressure, compared to the good sleep quality group (127.8 (120.7 - 134.9) mm Hg vs. 121.0 (114.7 - 127.3) mm Hg; P = 0.01). This difference was present even after adjustment for age, sex, alcohol drinking habit, smoking habit, behavior for lowering salt intake, body mass index, and sleep duration. Mean diastolic blood pressure also tended to be higher in the poor sleep quality group compared to that in the good sleep quality group (71.8 (66.2 - 77.3) mm Hg vs. 68.7 (63.8 - 73.6) mm Hg; P = 0.14). However, in participants aged ≥ 50 years, mean systolic and diastolic blood pressures were similar in the two sleep quality groups. The multivariate-adjusted regression model showed a statistically significant interaction between simple subjective sleep quality and age for systolic blood pressure (P value for interaction = 0.04), with a trend for a similar interaction with diastolic blood pressure (P value for interaction = 0.08) (Table 2).

The patterns for blood pressure in the two sleep quality groups were different between the three age strata (≤ 39, 40 - 59, or ≥ 60 years) (Supplementary Material 1, jocmr.elmerjournals.com). In participants aged ≤ 39 years, the poor sleep quality group tended to have higher adjusted mean systolic and diastolic blood pressures compared to the good sleep quality group; however, this difference was not statistically significant (123.4 (113.2 - 133.7) mm Hg vs. 117.2 (108.1 - 126.4) mm Hg; P = 0.09 for systolic blood pressure, and 67.8 (59.7 - 75.9) mm Hg vs. 63.6 (56.4 - 70.9) mm Hg; P = 0.14 for diastolic blood pressure). However, in participants aged 40 - 59 years and those aged ≥ 60 years, mean systolic and diastolic blood pressures were similar in the two sleep quality groups.

Discussion

This community-based, cross-sectional study carried out in Yonaguni Island, Okinawa prefecture, Japan, investigated whether poor sleep quality was associated with increased blood pressure in individuals with optimal sleep duration on weekdays (6 - 7.9 h/day) who were not taking sleep or antihypertensive medications. The study demonstrated that participants aged ≤ 49 years with optimal sleep duration but poor sleep quality had higher blood pressure levels compared to those with good sleep quality.

Table 1. Characteristics of the Study Participants[a] From Yonaguni Island, Okinawa, Japan, Grouped According to Simple Subjective Sleep Quality

	Overall (N = 169)	Simple subjective sleep quality		P value for difference
		Good	Poor	
Overall		N = 118	N = 51	
Age, years	48.8 (15.0)	49.5 (14.4)	47.3 (16.4)	0.38
Females	53.9% (91)	55.1% (65)	51.0% (26)	0.66
Current alcohol drinking	41.4% (70)	39.0% (46)	47.1% (24)	0.33
Current smoking	18.3% (31)	19.5% (23)	15.7% (8)	0.56
Not-lowering salt intake	39.6% (67)	36.4% (43)	47.1% (24)	0.20
Body mass index, kg/m^2	24.1 (5.0)	23.9 (4.8)	24.8 (5.5)	0.29
Sleep duration, h/day	6.8 (0.5)	6.9 (0.5)	6.7 (0.6)	0.17
Systolic blood pressure, mm Hg	125.7 (17.2)	124.7 (17.2)	127.9 (17.1)	0.26
Diastolic blood pressure, mm Hg	74.7 (11.3)	74.3 (11.0)	75.7 (12.0)	0.46
Aged ≤ 49 years	N = 93	N = 63	N = 30	
Age, years	37.6 (7.6)	38.3 (7.6)	36.1 (7.5)	0.18
Females	50.5% (47)	50.8% (32)	50.0% (15)	0.94
Current alcohol drinking	45.2% (42)	46.0% (29)	43.3% (13)	0.81
Current smoking	20.4% (19)	22.2% (14)	16.7% (5)	0.53
Not-lowering salt intake	52.7% (49)	50.8% (32)	56.7% (17)	0.60
Body mass index, kg/m^2	24.5 (5.9)	24.2 (5.6)	25.1 (6.5)	0.49
Sleep duration, h/day	6.8 (0.5)	6.9 (0.5)	6.7 (0.5)	0.12
Systolic blood pressure, mm Hg	121.0 (15.3)	118.4 (13.9)	126.4 (16.8)	0.02
Diastolic blood pressure, mm Hg	72.1 (11.3)	71.0 (10.5)	74.3 (12.8)	0.19
Aged ≥ 50 years	N = 76	N = 55	N = 21	
Age, years	62.6 (9.3)	62.3 (8.3)	63.3 (11.6)	0.66
Females	57.9% (44)	60.0% (33)	52.4% (11)	0.55
Current alcohol drinking	36.8% (28)	30.9% (17)	52.4% (11)	0.08
Current smoking	15.8% (12)	16.4% (9)	14.3% (3)	0.82
Not-lowering salt intake	23.7% (18)	20.0% (11)	33.3% (7)	0.22
Body mass index, kg/m^2	23.7 (3.6)	23.5 (3.7)	24.2 (3.5)	0.79
Sleep duration, h/day	6.8 (0.5)	6.8 (0.5)	6.8 (0.6)	0.38
Systolic blood pressure, mm Hg	131.4 (17.8)	131.8 (18.0)	130.1 (17.7)	0.36
Diastolic blood pressure, mm Hg	78.0 (10.5)	78.1 (10.5)	77.7 (10.7)	0.45

The data are presented for the total participants, as well as for participants stratified according to age (≤ 49 or ≥ 50 years). Data are expressed as mean (standard deviation) or % (number) of participants in that category. The unpaired *t*-test or Chi-square test was used to compare the characteristics in the two subjective sleep quality groups. [a]The study participants had a sleep duration of 6 - 7.9 h/day on weekdays and were not taking either sleep medication or antihypertensive medication.

This relationship remained even after adjustment for potential confounders, including relatively short periods of optimal sleep duration. In contrast, participants aged ≥ 50 years with or without poor sleep quality had similar blood pressure levels.

Similar to the current study, several relevant cross-sectional studies also assessed an individual's simple subjective feeling for sleep quality using a single item of the PSQI [12-14]. Liu et al showed that in a Chinese population, after adjustment for potential confounders including age, sex, and major risk factors for hypertension, the odds ratios (95% confidence intervals) for the presence of hypertension (systolic blood pressure ≥ 140 mm Hg, diastolic blood pressure ≥ 90 mm Hg), and/or taking antihypertensive medication were 1.82 (1.65 - 2.00) for "fairly good", 2.46 (2.00 - 3.03) for "fairly bad", and 1.91 (1.22 - 2.99) for "very bad", compared with simple subjective sleep quality being "very good" [14]. However, sleep duration was not taken into consideration in their analysis. The analytic procedure of this previous study may have been insufficient

Table 2. Mean Blood Pressure in Participants[a] Grouped According to Simple Subjective Sleep Quality

	Simple subjective sleep quality		P value
	Good	Poor	
Overall	N = 118	N = 51	
Systolic blood pressure, mm Hg			
Crude mean (95% CI)	124.7 (121.5 - 127.8)	127.9 (123.1 - 132.7)	0.26
Age and sex-adjusted mean (95% CI), model 1	128.7 (124.8 - 132.7)	132.6 (127.5 - 137.6)	0.15
Multivariate-adjusted mean (95% CI), model 2	126.2 (120.6 - 131.7)	128.9 (122.3 - 135.5)	0.28
Multivariate-adjusted mean (95% CI), model 3	126.2 (120.7 - 131.7)	128.5 (121.9 - 135.0)	0.36
Diastolic blood pressure, mm Hg			
Crude mean (95% CI)	74.3 (72.3 - 76.3)	75.7 (72.3 - 79.1)	0.46
Age and sex-adjusted mean (95% CI), model 1	77.6 (75.0 - 80.2)	79.2 (75.9 - 82.6)	0.36
Multivariate-adjusted mean (95% CI), model 2	73.5 (69.9 - 77.2)	74.4 (70.1 - 78.8)	0.59
Multivariate-adjusted mean (95% CI), model 3	73.5 (69.9 - 77.2)	74.2 (69.9 - 78.6)	0.69
Aged ≤ 49 years	N = 63	N = 30	
Systolic blood pressure, mm Hg			
Crude mean (95% CI)	118.4 (114.9 - 121.9)	126.4 (120.1 - 132.6)	0.02
Age and sex-adjusted mean (95% CI), model 1	125.8 (121.6 - 130.0)	134.1 (128.8 - 139.5)	0.005
Multivariate-adjusted mean (95% CI), model 2	121.1 (114.8 - 127.4)	128.0 (121.0 - 135.0)	0.01
Multivariate-adjusted mean (95% CI), model 3	121.0 (114.7 - 127.3)	127.8 (120.7 - 134.9)	0.01
Diastolic blood pressure, mm Hg			
Crude mean (95% CI)	71.0 (68.4 - 73.7)	74.3 (69.5 - 79.1)	0.19
Age and sex-adjusted mean (95% CI), model 1	75.2 (72.0 - 78.5)	79.3 (75.1 - 83.4)	0.07
Multivariate-adjusted mean (95% CI), model 2	68.7 (63.8 - 73.6)	72.0 (66.5 - 77.5)	0.12
Multivariate-adjusted mean (95% CI), model 3	68.7 (63.8 - 73.6)	71.8 (66.2 - 77.3)	0.14
Aged ≥ 50 years	N = 55	N = 21	
Systolic blood pressure, mm Hg			
Crude mean (95% CI)	131.8 (127.0 - 136.7)	130.1 (122.1 - 138.2)	0.71
Age and sex-adjusted mean (95% CI), model 1	131.9 (125.0 - 138.8)	129.8 (120.9 - 138.7)	0.66
Multivariate-adjusted mean (95% CI), model 2	129.9 (120.6 - 139.3)	126.5 (114.0 - 138.9)	0.45
Multivariate-adjusted mean (95% CI), model 3	130.6 (121.3 - 139.8)	126.9 (114.6 - 139.2)	0.43
Diastolic blood pressure, mm Hg			
Crude mean (95% CI)	78.1 (75.2 - 80.9)	77.7 (72.8 - 82.6)	0.89
Age and sex-adjusted mean (95% CI), model 1	79.8 (75.7 - 83.9)	79.3 (74.0 - 84.5)	0.85
Multivariate-adjusted mean (95% CI), model 2	78.8 (73.1 - 84.4)	77.7 (70.2 - 85.2)	0.70
Multivariate-adjusted mean (95% CI), model 3	79.1 (73.5 - 84.7)	78.0 (70.5 - 85.4)	0.68

The data are presented for the total participants as well as for participants stratified according to age (≤ 49 or ≥ 50 years). [a]The study participants had a sleep duration of 6 - 7.9 h/day on weekdays and were not taking either sleep medication or antihypertensive medication. The unpaired *t*-test or analysis of covariance was used to compare blood pressure in the two subjective sleep quality groups. Three different models of analysis of covariance were constructed as follows: model 1 was adjusted for age and sex; model 2 was adjusted for the same covariates used in model 1 in addition to alcohol drinking habit, smoking habit, behavior for lowering salt intake, and body mass index; and model 3 was adjusted for the same covariates used in model 2 in addition to sleep duration. CI: confidence interval.

because sleep issues are complicated. Some individuals may have poor sleep quality resulting from intended short sleep duration, whereas others may try to have long sleep duration to compensate for poor sleep quality. Two other relevant studies also observed similar findings but did not take sleep duration into consideration [12, 13]. To our knowledge, our study is the first to focus on individuals with optimal sleep duration and to suggest that an individual's simple subjective feeling of poor sleep quality may be a marker for increased blood pressure even in these individuals.

We observed that only participants in the young to early middle-aged stratum with poor sleep quality had higher systolic blood pressure levels compared to those with good sleep quality, with the interaction effect between age and sleep quality on systolic blood pressure being statistically significant. Unlike our study, Lu et al [12] observed a relationship between poor sleep quality and hypertension irrespective of age (≤ 45 or > 45 years), although the study design and statistical analysis were different from those used in our study. In general, the effects of each risk factor on the development of hypertension are attenuated with age [24, 25]. This phenomenon may be partially explained by the sympathetic nervous system being less responsive to stimuli with increasing age [26, 27]. Furthermore, the increased prevalence of other competing risk factors at older ages in general may also lead to an attenuated relationship of interest. However, this explanation was unlikely to be applicable to our study, which showed a similar prevalence of background characteristics for the ≤ 49-year and ≥ 50-year strata, with the exception of not-lowering their salt intake, the prevalence of which was rather lower in the older stratum. Because the number of participants was limited in our sub-analysis, caution is needed when interpreting the results. That is, our study may have missed statistically significant increases in blood pressure in participants aged ≥ 50 years because of a type II error caused by the smaller number of participants with poor sleep quality. However, in the more detailed age-stratified analysis, both the 40 - 59-year and ≥ 60-year strata, but not the ≤ 39-year stratum, showed no association, a finding that may still support the interaction effect between age and sleep quality on systolic blood pressure.

Sleep status has both qualitative and quantitative aspects, and therefore it is often difficult to determine the influence of each factor on health. Therefore, we focused on individuals with optimal sleep duration, using a simple, validated question, in order to simplify the meaning of poor sleep quality and to allow us to interpret the results more easily. This approach represents a methodological advantage in comparison with previous studies, although this approach, in turn, resulted in a small number of participants in our study. Evidence from previous studies may explain the mechanism for the relationship we observed between poor sleep quality and increased blood pressure [28-30]. For instance, sympathetic overactivity that accompanies various sleep disorders is associated with increased blood pressure [28, 29]. Similarly, psychological stress leads to insufficient sleep and induces retention of sodium and fluid, thereby increasing blood pressure [30]. There may also have been a residual confounding effect of sleep apnea, a sleep disorder that increases the risk of hypertension [31], thereby affecting the association between sleep quality and blood pressure. For this reason, in our analysis we adjusted the data for body mass index, a major indicator for sleep apnea [32]. The simple assessment of sleep quality was the key point of this study for extrapolating the results to the practice of prevention and management of hypertension. A future large-scale cohort study that also collects data on physical and psychological factors that may affect simple subjective sleep quality is warranted to provide more useful evidence on this topic.

The present study had several limitations that should be acknowledged. First, the health check-up facility that helped us with this study measured blood pressure twice only if the first measurement showed high levels of blood pressure. Assuming our hypothesis is true, individuals in the poor sleep quality group could initially have had higher blood pressure levels than those in the good sleep quality group, and therefore were more likely to subsequently have had two blood pressure measurements. Due to the theory of "regression towards the mean", this trend of two blood pressure measurements in the poor sleep quality group may have led to lower blood pressure levels than the level based on the single measurement [33]. This possibility may have caused the results of our study to be underestimated. In addition, due to the lack of data on the time when blood pressure was measured, we could not take this factor into account in the analysis. Second, due to the lack of data on sleep apnea, we could not take this condition directly into account in the analysis, although we alternatively allowed for body mass index. Third, with respect to excessive salt intake, which was assumed to be a confounding factor, we used the data on self-reported efforts to reduce salt intake rather than the actual amount of salt intake measured by an objective evaluation. Fourth, cross-sectional studies like ours cannot guarantee a cause-effect relationship between poor sleep quality and increased blood pressure. Even though the cause-and-effect relationship was true, the magnitude of the association between simple subjective sleep quality and blood pressure is different from that measured in cohort studies. Finally, our study population comprised residents in a small remote island, where the socioeconomic environments are quite different from those in the urban and rural areas of the main island of Japan. Therefore, lifestyle factors resulting from the socioeconomic environments in this community may have affected sleep quality in the study population. Accordingly, caution is advised when generalizing the results of the present study.

Conclusions

This study showed that an individual's simple subjective feeling of poor sleep quality was associated with increased systolic blood pressure in young to early middle-aged individuals with optimal sleep duration. The results of this study emphasize the importance of easily assessing simple subjective sleep quality in clinical settings, even in individuals with optimal sleep duration, in order to prevent and manage hypertension.

Supplementary Material

Suppl 1. Mean blood pressure in participants grouped according to simple subjective sleep quality.

Acknowledgments

We express special gratitude to all the study participants, the Yonaguni municipal government officers, and other individuals who were involved in the Yonaguni Island study.

Financial Disclosure

The authors received no funding for this study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Informed Consent

After explanation of the study requirements, each participant provided their written, informed consent by placing a check mark on the participation agreement form.

Author Contributions

YF and KN were involved in the fundamental design of the study and data acquisition. KT and KN conceived the concept of the current report, performed the statistical analyses, and wrote the manuscript. All authors interpreted the results. YF made critical revisions to the manuscript. KN supervised the study. All authors read and approved the final manuscript.

Data Availability

Any inquiries regarding supporting data availability of this study should be directed to the corresponding author.

Abbreviations

PSQI: Pittsburgh Sleep Quality Index

References

1. Kokubo Y, Kamide K, Okamura T, Watanabe M, Higashiyama A, Kawanishi K, Okayama A, et al. Impact of high-normal blood pressure on the risk of cardiovascular disease in a Japanese urban cohort: the Suita study. Hypertension. 2008;52(4):652-659. doi pubmed
2. Arima H, Tanizaki Y, Yonemoto K, Doi Y, Ninomiya T, Hata J, Fukuhara M, et al. Impact of blood pressure levels on different types of stroke: the Hisayama study. J Hypertens. 2009;27(12):2437-2443. doi pubmed
3. Fujiyoshi A, Ohkubo T, Miura K, Murakami Y, Nagasawa SY, Okamura T, Ueshima H, et al. Blood pressure categories and long-term risk of cardiovascular disease according to age group in Japanese men and women. Hypertens Res. 2012;35(9):947-953. doi pubmed
4. Ikeda N, Inoue M, Iso H, Ikeda S, Satoh T, Noda M, Mizoue T, et al. Adult mortality attributable to preventable risk factors for non-communicable diseases and injuries in Japan: a comparative risk assessment. PLoS Med. 2012;9(1):e1001160. doi pubmed
5. World Health Organization. Global report on hypertension: the race against a silent killer. October 1, 2024. Available online: https://www.who.int/publications/i/item/9789240081062/.
6. Umemura S, Arima H, Arima S, Asayama K, Dohi Y, Hirooka Y, Horio T, et al. The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2019). Hypertens Res. 2019;42(9):1235-1481. doi pubmed
7. Wang Q, Xi B, Liu M, Zhang Y, Fu M. Short sleep duration is associated with hypertension risk among adults: a systematic review and meta-analysis. Hypertens Res. 2012;35(10):1012-1018. doi pubmed
8. Lo K, Woo B, Wong M, Tam W. Subjective sleep quality, blood pressure, and hypertension: a meta-analysis. J Clin Hypertens (Greenwich). 2018;20(3):592-605. doi pubmed
9. Buysse DJ, Reynolds CF, 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193-213. doi pubmed
10. Bush AL, Armento ME, Weiss BJ, Rhoades HM, Novy DM, Wilson NL, Kunik ME, et al. The Pittsburgh Sleep Quality Index in older primary care patients with generalized anxiety disorder: psychometrics and outcomes following cognitive behavioral therapy. Psychiatry Res. 2012;199(1):24-30. doi pubmed
11. Carpenter JS, Andrykowski MA. Psychometric evaluation of the pittsburgh sleep quality index. J Psychosom Res. 1998;45(1):5-13. doi pubmed
12. Lu K, Ding R, Tang Q, Chen J, Wang L, Wang C, Wu S, et al. Association between self-reported global sleep status and prevalence of hypertension in Chinese adults: data from the Kailuan community. Int J Environ Res Public Health. 2015;12(1):488-503. doi pubmed
13. Chen S, Song X, Shi H, Li J, Ma S, Chen L, Lu Y, et al. Association between sleep quality and hypertension in Chinese adults: a cross-sectional analysis in the Tianning cohort. Nat Sci Sleep. 2022;14:2097-2105. doi pubmed
14. Liu RQ, Qian Z, Trevathan E, Chang JJ, Zelicoff A, Hao YT, Lin S, et al. Poor sleep quality associated with high risk of hypertension and elevated blood pressure in China: results from a large population-based study. Hypertens Res. 2016;39(1):54-59. doi pubmed
15. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. J Psychosom Res. 1997;42(6):583-596. doi pubmed
16. Fukumine Y, Nakamura K. Obesity and hypertension from a public health perspective in a small remote island of Okinawa, Japan. Hypertens Res. 2023;46(8):1850-1859. doi pubmed
17. Garde AH, Hansen AM, Holtermann A, Gyntelberg F, Suadicani P. Sleep duration and ischemic heart disease and all-cause mortality: prospective cohort study on effects of tranquilizers/hypnotics and perceived stress. Scand J Work Environ Health. 2013;39(6):550-558. doi

pubmed
18. Yadav D, Hyun DS, Ahn SV, Koh SB, Kim JY. A prospective study of the association between total sleep duration and incident hypertension. J Clin Hypertens (Greenwich). 2017;19(5):550-557. doi pubmed
19. Doi Y, Minowa M, Uchiyama M, Okawa M. Development of the Japanese version of the Pittsburgh Sleep Quality Index. Jpn J Psychiatry Treat. 1998;13(6):755-763 [in Japanese].
20. Nakashima M, Morikawa Y, Sakurai M, Nakamura K, Miura K, Ishizaki M, Kido T, et al. Association between long working hours and sleep problems in white-collar workers. J Sleep Res. 2011;20(1 Pt 1):110-116. doi pubmed
21. Nakamura K, Hui SP, Ukawa S, Okada E, Nakagawa T, Okabe H, Chen Z, et al. Serum 25-hydroxyvitamin D(3) levels and poor sleep quality in a Japanese population: the DOSANCO Health Study. Sleep Med. 2019;57:135-140. doi pubmed
22. Kim SJ, Lee YJ, Cho SJ, Cho IH, Lim W, Lim W. Relationship between weekend catch-up sleep and poor performance on attention tasks in Korean adolescents. Arch Pediatr Adolesc Med. 2011;165(9):806-812. doi pubmed
23. Ministry of Health, Labour and Welfare, Japan. The National Health and Nutrition survey in Japan. October 1, 2024. Available online: https://www.mhlw.go.jp/bunya/kenkou/kenkou_eiyou_chousa.html [in Japanese].
24. Cohen L, Curhan GC, Forman JP. Influence of age on the association between lifestyle factors and risk of hypertension. J Am Soc Hypertens. 2012;6(4):284-290. doi pubmed
25. Nguyen B, Bauman A, Ding D. Association between lifestyle risk factors and incident hypertension among middle-aged and older Australians. Prev Med. 2019;118:73-80. doi pubmed
26. Hogikyan RV, Supiano MA. Arterial alpha-adrenergic responsiveness is decreased and SNS activity is increased in older humans. Am J Physiol. 1994;266(5 Pt 1):E717-724. doi pubmed
27. Esler MD, Thompson JM, Kaye DM, Turner AG, Jennings GL, Cox HS, Lambert GW, et al. Effects of aging on the responsiveness of the human cardiac sympathetic nerves to stressors. Circulation. 1995;91(2):351-358. doi pubmed
28. Joyner MJ, Charkoudian N, Wallin BG. Sympathetic nervous system and blood pressure in humans: individualized patterns of regulation and their implications. Hypertension. 2010;56(1):10-16. doi pubmed
29. Chouchou F, Pichot V, Pepin JL, Tamisier R, Celle S, Maudoux D, Garcin A, et al. Sympathetic overactivity due to sleep fragmentation is associated with elevated diurnal systolic blood pressure in healthy elderly subjects: the PROOF-SYNAPSE study. Eur Heart J. 2013;34(28):2122-2131. doi pubmed
30. Light KC, Koepke JP, Obrist PA, Willis PW IV. Psychological stress induces sodium and fluid retention in men at high risk for hypertension. Science. 1983;220(4595):429-431. doi pubmed
31. Hou H, Zhao Y, Yu W, Dong H, Xue X, Ding J, Xing W, et al. Association of obstructive sleep apnea with hypertension: A systematic review and meta-analysis. J Glob Health. 2018;8(1):010405. doi pubmed
32. Veasey SC, Rosen IM. Obstructive Sleep Apnea in Adults. N Engl J Med. 2019;380(15):1442-1449. doi pubmed
33. Porta MS, Greenland S, Hernan M, Silva I dos S, Last JM. A Dictionary of Epidemiology, 6th ed. New York: Oxford University Press, 2014.