https://doi.org/10.5664/jcsm.10168

JCSM | Journal of Clinical Sleep Medicine

SCIENTIFIC INVESTIGATIONS

24-hour urinary potassium excretion is negatively associated with self-reported sleep quality in the general population, independently of sleep-disordered breathing

Mei Li, MS*; Mulalibieke Heizhati, PhD*; Lin Wang, PhD; Zhongrong Wang, MS; Reyila Abudoureyimu, MS; Zhikang Yang, MS; Fengyu Pan, MS; Le Sun; Wei Li; Jing Li; Mengyue Lin, MS; Lin Gan, MS; Shan Lu, MS; Nanfang Li, PhD

*Hypertension Center of People's Hospital of Xinjiang Uygur Autonomous Region, Xinjiang Hypertension Institute, National Health Committee Key Laboratory of Hypertension Clinical Research, Key Laboratory of Xinjiang Uygur Autonomous Region, Hypertension Research Laboratory, Xinjiang Clinical Medical Research Center for Hypertension (Cardio-Cerebrovascular) Diseases, Urumqi, Xinjiang China; *Contributed equally as co–first authors*

Study Objectives: To investigate the association of 24-hour urinary potassium excretion with self-reported sleep quality in the general population.

Methods: In this cross-sectional study, a population of patients aged 18 years or older was randomly selected from Xinjiang, China in 2019, 24-hour urine samples collected, and Pittsburgh Sleep Quality Index (PSQI) questionnaires assessed. Participants were divided into 2 groups (upper and lower median of 24-hour urinary potassium excretion). Poor sleep quality was defined as PSQI global score ≥ 6. Associations between 24-hour urinary potassium excretion and [24.8 mmol/L] sleep quality were assessed by multiple logistic regression analysis in total participants and those stratified by sex.

Results: In total, 24-hour urine samples were collected from 1,147 participants, of whom data for those with complete urine samples and PSQI data were analyzed (n = 727; mean age = 48.7 years; percentage of women = 62%). Compared with the upper median group for 24-hour urinary potassium excretion, the lower median group showed a significantly higher PSQI global score (6 vs 5, $P = .011$), and prevalence of poor sleep quality (51.7% vs 42.2%, $P = .011$). In a fully-adjusted model of multivariate logistic regression, the lower median group showed 1.50-fold increased odds for presence of poor sleep quality (95% confidence interval: 1.01–2.24, $P = .045$). Sex-specific analyses translated these results to women, but not to men.

Conclusions: These results suggest that low potassium intake, indicated by lower potassium excretion, is associated with poor sleep quality in the general population, especially among women. Therefore, additional research is necessary to clarify the effect of increasing potassium intake to improve sleep quality.

Keywords: potassium intake, 24-hour urinary potassium excretion, subjective sleep quality, general population

Citation: Li M, Heizhati M, Wang L, et al. 24-hour urinary potassium excretion is negatively associated with self-reported sleep quality in the general population, independently of sleep-disordered breathing. *J Clin Sleep Med*. 2022;18(11):2589–2596.

BRIEF SUMMARY

Current Knowledge/Study Rationale: Potassium is one of the possible determinants of sleep. Recent studies suggest that potassium intake is associated with sleep quality and quantity, although findings are inconclusive. Therefore, the goal of the study was to investigate the association of 24-hour urinary potassium excretion with self-reported sleep quality in the general population.

Study Impact: These results suggest that low potassium intake, indicated by lower potassium excretion, is associated with poor sleep quality in the general population, especially among women. Additional research is necessary to clarify the effect of increasing potassium intake to improve sleep quality.

INTRODUCTION

Sleep is a universal need and accounts for approximately one-third of a person's lifetime. The importance of sleep health in the development and management of chronic disease has been emphasized[1,2]; growing evidence shows that poor sleep quality, with a prevalence of 31.6%–67.3% in adults (higher in females than males: 65.1% vs 49.8%),[3–6] is associated with cardiometabolic risk factors and morbidity[7,8] and mortality.[9] Therefore, improved understanding of modifiable risk factors is critical for prevention.

Sleep quality is affected by a number of modifiable risk factors such as exercise,[10] psychological stress,[11] and dietary components including potassium.[12–17] Recent studies show that higher potassium intake is associated with better sleep quality in adults[18]; lower potassium intake is associated with short sleep duration[19] and diurnal sleepiness,[20] which are characteristics of changes in sleep quality. In addition, patients with hypertension who have lower serum potassium concentration were objectively assessed and found to have lengthened stage 1 sleep, a parameter of changes in sleep quality.[21] Therefore, it might be reasonable to speculate that potassium intake is associated with changes in sleep quality. Possible mechanisms may include the activation of potassium channels such as via thermosensitive γ-aminobutyric acid transmission, which plays a critical role in sleep regulation.[22–24] However, current results obtained in selected clinical populations[14] are sometimes inconsistent among studies and between male and female

patients[12,19,20]; previous studies used questionnaires to assess potassium intake[18–20] with the possibility of overestimation via self-report,[25] or the studies failed to assess comprehensive sleep quality,[19,20] making the strength of the association between potassium intake and sleep quality inconclusive, especially in the general population.

This investigation aimed to explore the relationship between 24-hour urinary potassium excretion using 24-hour urine sample and sleep quality self-reported with the Pittsburgh Sleep Quality Index (PSQI) in the general population, because clarifying this relationship at the population level could lead to population-based sleep quality optimization programs focused on increasing potassium intake, both of which have been shown to be feasible and result in disease prevention.[26–28] In addition, the effects of patient sex on the association of 24-hour urinary potassium excretion and self-reported sleep quality were considered by performing sex-specific analysis, because previous studies reported inconsistent prevalence and relevant factors of poor sleep quality between males and females.[12,19,20]

METHODS

Study population

This was a cross-sectional study. A multistage proportional random sampling method was used to obtain a study population of patients aged 18 years or older from Xinjiang, China in 2019; and the methods were described in detail in a previous study.[29] In brief, during the first stage, Emin County was divided into 20 sites. During the second stage, 10 sites were selected using a simple random sampling method. During the third stage, participants from each site were selected. Inclusion criteria encompassed (1) local inhabitants aged 18 years or older, (2) residence at current address for 6 months or longer, and (3) agreement to participate and sign an informed consent form. The physically or mentally disabled, and patients still having a menstrual cycle or who were pregnant were excluded.

The Independent Ethics Committee of People's Hospital of Xinjiang Uygur Autonomous Region approved the present study. Signed informed consent was obtained from all of the eligible participants.

Data collection

During a face-to-face interview, each participant completed questionnaires including PSQI, Lausanne NoSAS (Neck circumference, Obesity, Snoring, Age, Sex) score,[30] Zung Self-Rating Anxiety Scale (SAS), and Self-Rating Depression Scale. Data on demographic characteristics, education attainment status, lifestyles, medical histories, and therapeutic agents were also collected. Blood pressure (BP), height, weight, and waist circumference were measured according to the protocols.

Three BP measurements were taken from the patient's unclothed right arm immediately after at least a 5-minute rest while seated and at intervals of at least 1 minute using the Omron HEM-1000 electronic sphygmomanometer. BP was presented as the mean of 3 measurements. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, with participants in lightweight clothing and without shoes. Waist circumference was measured at the midpoint between the lower rib and upper margin of the iliac crest to the nearest 0.1 cm at the end of normal expiration. Body mass index (BMI) was calculated by dividing weight by height squared (kg/m^2).

24-hour urine and blood sample collection and measurement

A timed 24-hour urine specimen was collected from each participant. In brief, in-person timed collections began at a temporary urine collection point established at each site on the first day and were completed the next day. Each participant was given verbal and written instructions on when to start and complete the process and how to collect the sample. Urine samples were collected from 9:00 AM to 9:00 AM the next day after excluding the first sample of the first day. On the second day, total volume of each collection was measured and recorded. Urine samples were collected in 5 respective tubes of 5 mL and temporarily stored at −20°C, and the rest of the samples were discarded.

Blood samples were obtained on the second day of urine sample collection, following overnight fasting. Measurement of urinary creatinine; electrolytes including sodium, potassium, and chloride, and serum creatinine; glucose; and lipid profiles was conducted at People's Hospital of Tacheng on the same day of sample collection, and the specimens were stored in portable refrigerators during delivery.

Completeness of urine samples was evaluated using the following criteria: (1) total urine volume ≥ 500 mL, (2) collection duration of 20 hours or longer, (3) minimal urine lost during collection, (4) 24-hour urinary creatinine per kilogram of body weight ≥ 20 mg/kg in men and ≥ 15 mg/kg in women younger than 50 years and ≥ 10 mg/kg in men and ≥ 7.5 mg/kg in women 50 years or older.[31,32]

Sleep quality assessment

Self-reported sleep quality was assessed using the PSQI scale. The PSQI is a popular and accepted instrument of choice because of its high internal consistency (α = 0.83), test-retest reliability (r = .85), and moderate structural validity identifying patients with poor sleep quality in clinical and nonclinical populations.[33] The PSQI consists of 19 items that are coded on a 4-point scale (0–3) to obtain 7 elements: self-reported sleep quality (a self-reported feeling of satisfaction in daily sleep), sleep disturbance (interruption of sleep), daytime dysfunction (trouble staying awake while engaging in social activity), sleep onset latency (length of time for transition from full wakefulness to sleep), habitual sleep efficiency (proportion of hours slept to total hours in bed), sleep duration, and use of sleep medication.[33]

The sum of all subscale scores represents the total sleep quality score ranging between 0 and 21, with higher scores representing poorer sleep quality. Any participant with a score of 6 or higher was considered to have poor sleep quality.[33]

Definitions of covariates

Hypertension is defined as systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg, and/or administration of antihypertensive medication within the previous 2 weeks. Diabetes mellitus is

defined as fasting blood glucose ≥ 7.0 mmol/L, and/or self-reported previous diagnosis by physicians and/or intake of hypoglycemic agents within the past 2 weeks. Dyslipidemia is defined as total cholesterol ≥ 6.2 mmol/L and/or triglyceride ≥ 2.3 mmol/L and/or high-density lipoprotein cholesterol < 1.0 mmol/L and/or low-density lipoprotein cholesterol ≥ 4.2 mmol/L and/or administration of treatment during the past 2 weeks. Overweight and obesity are defined as BMI ≥ 25 kg/m^2 and BMI ≥ 30 kg/m^2, respectively. Abdominal obesity is defined as having a waist circumference ≥ 102 cm for men and ≥ 88 cm for women. Probable sleep-disordered breathing (SDB) was identified using a threshold of 8 points or more of the NoSAS score.[30] The NoSAS score ranges from 0 to 17, allocates 4 points for having a neck circumference of more than 40 cm, 3 points for having a BMI of 25 kg/m^2 to less than 30 kg/m^2, or 5 points for having a BMI of 30 kg/m^2 or higher, 2 points for snoring, 4 points for being older than 55 years, and 2 points for being male. SAS and self-rating depression scales were used to assess anxiety and depression status; depression was defined as self-rating depression scale standard score ≥ 50 and anxiety was defined as SAS standard score ≥ 53.[34] Education attainment status was classified as > and ≤ senior high school (12 years of education).

Statistical analysis

Participants were divided into 2 groups above and below median (upper median and lower median, respectively) 24-hour urinary potassium excretion, based on the median excretion of 24.8 mmol/L. Stratified analysis was also performed adjusted by sex. Continuous variables were presented as mean ± standard deviation and compared between groups using the *t* test if normally distributed; otherwise these were presented as median (25th, 75th percentile) and compared by Mann-Whitney *U* test. Categorical variables were expressed as proportion (%) and frequency (n) and compared between groups using the Chi-square test. Logistic regression analysis was performed to assess the association between 24-hour urinary potassium excretion with presence of poor sleep quality. Unadjusted and adjusted odds ratios (ORs) and 95% confidence intervals (95% CI) of lower vs upper medians for 24-hour urinary potassium excretion for presence of poor sleep were calculated. Multiple logistic regression analysis included unadjusted model, model 1, and model 2. Model 1 was adjusted for age, sex education status, occupation, smoking status, alcohol assumption, systolic BP, waist circumference, dyslipidemia, diabetes mellitus, estimated glomerular filtration rate, 24-hour urinary sodium excretion, and anxiety and depression status. Model 2 was further adjusted for probable SDB on the basis of model 1. Tolerance and variance inflation factor of multiple linear regression were used to evaluate collinearity among variables. Collinearity was considered when tolerance was less than 0.1 or variance inflation factor greater than 10. Sensitivity analysis was conducted by exclusion of participants undergoing antihypertensive treatment for comparison of PSQI global score and of prevalence of poor sleep quality between groups and for regression analysis. Results were considered statistically significant for 2-tailed value of $P < .05$. All statistical analyses were performed with SPSS statistical software, version 24.0 (Chicago, IL).

RESULTS

There were a total of 1,147 participants invited to the study; 727 of these submitted a quality urine sample and complete PSQI data to compose by the present analytical sample (**Figure 1**). Characteristics of participants with qualified and unqualified 24-hour urine samples are presented in **Table S1** in the supplemental material.

As shown in **Table 1**, the lower median 24-hour urinary potassium excretion group (n = 366) showed significantly older age, higher systolic BP, lower fasting blood glucose, lower triglyceride, lower alcohol intake, and higher presence of hypertension compared with the upper median group (n = 361). Characteristics of participants stratified by sex are shown in **Table S2**.

The lower median 24-hour urinary potassium excretion group showed significantly higher PSQI global score [6 (3,8.3) vs 5 (3,8), $P = .011$] and presence of poor sleep quality (51.7% vs 42.2%, $P = .011$), compared with the upper median group (**Table 2**). Further sex-specific analysis showed significantly higher PSQI global score [6 (4,9) vs 5 (3,8), $P = .012$] and presence of poor sleep quality (59% vs 47.2%, $P = .008$) in women than men.

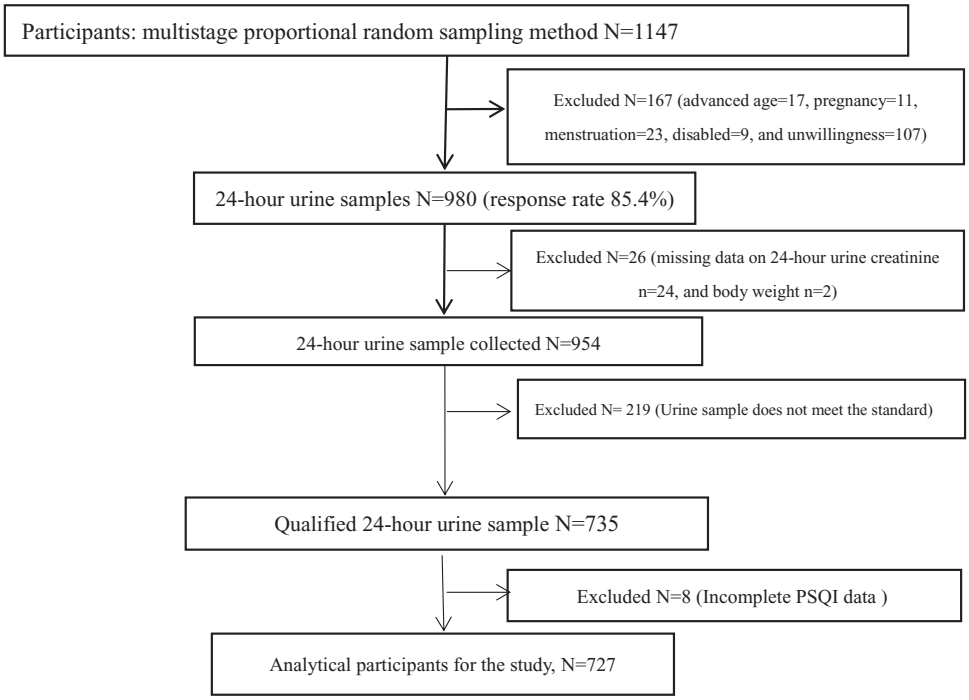
As outlined in **Table 3**, the lower median 24-hour urinary potassium excretion group showed significantly higher odds for presence of poor sleep quality (OR = 1.46, 95% CI: 1.09–1.96, $P = .017$) in total participants in the unadjusted model, remaining significant in model 1 (OR = 1.50, 95% CI: 1.01–2.23, $P = .045$) and in model 2 (OR = 1.50, 95% CI: 1.01–2.24, $P = .045$). In further sex-specific analysis, women in the lower median 24-hour urinary potassium excretion group showed a 1.65-fold increased odds for presence of poor sleep quality (95% CI:1.01,2.71, $P = .047$), compared with the higher median group.

In sensitivity analysis, the lower median 24-hour urinary potassium excretion group showed significantly higher global PSQI score and presence of poor sleep quality than did higher median groups in total and in women (**Table 2**). In sensitivity analysis of logistic regression, the lower median 24-hour urinary potassium excretion group showed significantly higher odds for presence of poor sleep quality than did higher median groups in total (OR = 1.56, 95% CI: 1.00, 2.42, $P = .047$) participants and marginally in women participants (OR = 1.67, 95% CI: 1.00, 2.77, $P = .050$) (lower part in **Table 3**).

DISCUSSION

In the present study, the association of 24-hour urinary potassium excretion with self-reported sleep quality was assessed using currently recommended criteria and standards for assessment of potassium intake and PSQI scale in a relatively large randomly selected general population. Main results encompass the following: First, those participants with lower 24-hour urinary potassium excretion showed higher PSQI global score and prevalent self-reported poor sleep quality. Second, participants in the lower median 24-hour urinary potassium excretion group

Figure 1—Flow chart of selection participants.



show 1.50-fold greater odds for presence of self-reported poor sleep quality, independent of probable SDB, compared with the higher median group. Third, sex-specific analyses translated these results to women, but not to men.

Results from the present study may add some evidence to previous findings and extend some clinical observations to the general population that lower potassium intake is associated with poor self-reported sleep quality.[13,16] Recent studies have shown that lower potassium intake is significantly associated with lower sleep efficiency[35] and higher potassium intake with better sleep quality,[14] despite methodologic differences. Other studies reveal that lower intake of fruits and vegetables, well-known dietary sources of potassium, is associated with poor sleep quality and longer sleep onset latency.[18] In the Dietary Approaches to Stop Hypertension study, increased potassium intake is inversely associated with sleepiness and sleep disturbance.[20]

A major strength of this investigation is the number of covariates included in the regression analysis, such as depression, anxiety, and probable SDB. Importantly, the association between 24-hour urinary potassium excretion and PSQI global score and poor sleep quality is independent of the presence of SDB, which may imply the potential for sleep quality improvement through increasing potassium intake using supplements or potassium-rich salt at population level.[36,37] Plausibly, there is high-quality emerging evidence that potassium-rich salt substitutes delay the incidence of hypertension in the normotensive population, help lower BP in those with hypertension,[27] and lower the rates of adverse cardiovascular events and all-cause death in high-risk populations.[26] Furthermore, in a recent randomized clinical trial conducted in young patients with excess weight and adults with obesity, sleep extension intervention (extending bedtime to 8.5 hours) showed a significant decrease in energy intake compared with habitual sleepers (< 6.5 hours). The change in sleep duration was inversely correlated with the change in energy intake, suggesting that improving and maintaining healthy sleep duration could be part of obesity prevention and weight loss programs.[28]

Another observation in the present study is that 24-hour urinary potassium excretion is associated with PSQI global score and presence of poor sleep quality in women participants in sex-specific analysis. Consistently, in a large population-based study, the potassium component of the Dietary Approaches to Stop Hypertension score was inversely associated with sleepiness and sleep disturbance among women.[20] Moreover, in a group of young Japanese women, later sleep timing (later midpoint of sleep) was significantly associated with a lower energy-adjusted intake of nutrients including potassium.[38] However, others did not report such sex-specific differences in the association of nutrient intake, including potassium, and changes in sleep quality.[13,14] Simultaneously, in a previous study performed in patients with hypertension, a significantly strong correlation was identified between serum potassium and rapid eye movement sleep stage in men.[21] These inconsistencies may be associated with differences in risk factors of sleep quality between the sexes. For instance, stress (depression) and physical activity are risk factors for poor sleep quality in women,[39] and alcohol consumption is a risk factor in men.[40] In addition, a small study sample of men may be another possible factor for the present observation. Although 24-hour urinary potassium excretion is more likely to affect sleep quality in

Table 1—Characteristics of the study population according to median of 24-hour urinary potassium (mmol/L).

Characteristics	Total	24-h UK < 24.8 mmol/L	24-h UK ≥ 24.8 mmol/L	t,Z,x^2/*P*
N	727	366	361	
Age (years)	48.7 (35.5,56.1)	50.8 (38.6,56.8)	47.0 (34.0,55.0)	–2.88/0.004
Sex (men, %)	276 (38.0)	130 (35.5)	146 (40.4)	1.87/0.171
Ethnicity (Han/others)	338/389	121/245	217/144	53.46/< 0.001
Education (> senior high, n,%)	170 (23.4)	79 (21.6)	91 (51.2)	1.33/0.143
Occupation (working, n,%)	599 (82.3)	300 (82.0)	299 (82.5)	0.09/0.578
Cigarette consumption (n, %)	153 (21.2)	71 (19.6)	82 (22.8)	1.16/0.317
Alcohol intake (n, %)	309 (42.7)	131 (35.8)	178 (49.3)	13.58/< 0.001
BMI (kg/m^2)	26.2 ± 4.4	26.1 ± 4.2	26.5 ± 4.8	–0.02/0.984
BMI: 25–30 kg/m^2	361 (49.4)	171 (46.7)	190 (52.6)	3.47/0.176
BMI: ≥ 30 kg/m^2	138 (19)	78 (21.3)	60 (16.6)	
Abdominal circumference (cm)	92.0 (82.9,99.5)	91.8 (82.0,99.9)	92.0 (83.1,99.0)	–0.51/0.639
Abdominal obesity (n, %)	382 (52.4)	189 (51.6)	193 (53.5)	0.24/0.623
Hypertension (n, %)	178 (24.7)	104 (28.4)	74 (20.5)	6.16/0.013
Antihypertensive agent intake (n,%)	132 (18.2)	80 (21.9)	52 (14.4)	6.79/0.009
Systolic blood pressure (mm Hg)	125.0 (114.7,139.0)	127.0 (115.0,141.7)	122.3 (113.9,136.1)	–2.49/0.013
Diastolic blood pressure (mm Hg)	79.3 (72.3,88.7)	80.3 (71.6,89.3)	78.3 (72.7,86.8)	–0.85/0.398
Fasting blood glucose (mmol/L)	5.1 (4.6,5.8)	5.0 (4.5,5.7)	5.2 (4.6,5.9)	–2.54/0.011
Diabetes (n, %)	61 (9.7)	36 (11.0)	25 (8.3)	1.34/0.282
Serum total cholesterol (mmol/L)	4.5 (3.8,5.2)	4.5 (3.8,5.3)	4.5 (3.8,5.2)	–0.68/0.497
Serum triglyceride (mmol/L)	1.1 (0.7,1.6)	1.0 (0.7,1.5)	1.2 (0.8,1.8)	–3.48/0.001
Dyslipidemia (n, %)	150 (24.1)	75 (23.3)	75 (24.9)	0.23/0.641
No-SAS score	5.0 (3.0,7.0)	5.0 (3.0,7.0)	4.0 (3.0,7.0)	–1.09/0.276
Sleep-disordered breathing (n, %)	135 (18.6)	70 (19.1)	65 (18.0)	0.15/0.704
Self-assessed anxiety (n, %)	77 (10.6)	42 (11.5)	35 (9.7)	0.61/0.738
Self-assessed depression (n, %)	113 (15.6)	68 (18.6)	45 (12.6)	5.03/0.031
Serum creatinine (mmol/L)	68.0 (53.9,86.1)	66.7 (53.3,83.4)	69.2 (54.0,89.0)	–1.34/0.181
eGFR (mL/min*1.73 m^2)	100.8 (76.4,133.5)	100.1 (77.9,128.7)	106.5 (74.5,141.9)	–0.92/0.357
24-Hour urinary sodium (mmol)	151.7 (108.8,202.7)	157.3 (112.1,210.7)	150.0 (105.9,198.3)	–1.20/0.230
24-Hour urinary potassium (mmol/L)	24.8 (18.3,32.8)	18.3 (14.9,21.3)	32.9 (29.0,39.0)	–23.32/< 0.001
24-Hour urinary creatinine (mmol)	8.5 (6.7,10.8)	7.9 (6.0,10.0)	9.1 (7.2,1.7)	–5.95/< 0.001
24-Hour urine volume (L)	1.25 (0.93,1.63)	1.47 (1.17,1.87)	1.07 (0.87,1.34)	–11.45/< 0.001

Continuous variables are presented as means ± SDs (M ± SD) and were analyzed using *t* test if normally distributed, otherwise, presented as median (25th, 75th percentile) and analyzed by Mann-Whitney *U* test. Categorical variables were expressed as proportion (%) and frequency (n), in which ordinal variables were analyzed with *U* test or H test and others were analyzed using Chi-square test. BMI = body mass index, eGFR = estimated glomerular filtration rate, Na/K = sodium to potassium ratio, SAS, self-rating anxiety scale, SD = standard deviation, UK = urinary potassium.

women, the causal pathway of the two is unclear. Additional studies are required to investigate the underlying mechanisms that link 24-hour urinary potassium excretion, sex, and sleep quality.

A key strength of this study is the objective measurement of potassium excretion using 24-hour urine samples, which may be more beneficial than food frequency methods or questionnaire survey methods. In addition, the present study was conducted in the general population, which may power the extrapolation of the results. However, the present study has several limitations. First, the cross-sectional nature of the study did not allow a causal relationship to be drawn between 24-hour urinary potassium excretion and sleep quality. However, major observations are consistent with those of previous studies. Second, SDB was assessed using the NoSAS score and not objective measurements such as polysomnography, which may have introduced some bias to the results considering its subjectivity. The NoSAS score has shown high sensitivity (79%) and specificity (69%) for SDB screening, compared with polysomnography, and has been validated in a Chinese population.[41–43] Third, it is not feasible to perform polysomnography in population-based studies due to its cost and technique dependence. Potassium excretion or intake

Table 2—Comparison of PSQI score and prevalent poor sleep quality by median of 24-hour urinary potassium and sensitivity analysis.

	Total	24-h UK < 24.8 mmol/L	24-h UK ≥ 24.8 mmol/L	x^2/*P*
Total	727	366	361	
Global PSQI score	5 (3,8)	6 (3,8.3)	5 (3,8)	–2.550.011
Poor sleep quality (n,%)	339 (46.6)	187 (51.7)	152 (42.2)	6.41/0.011
Men	274	128	146	
Global PSQI score	4 (3,7)	4 (2.3,7.0)	4 (3,6)	–0.39/0.695
Poor sleep quality (n,%)	100 (36.5)	49 (38.3)	51 (34.9)	0.33/0.327
Women	448	234	214	
Global PSQI score	6 (3,9)	6 (4,9)	5 (3,8)	–2.51/0.012
Poor sleep quality (n,%)	239 (53.3)	138 (59.0)	101 (47.2)	6.23/0.008
Sensitivity Analysis by Exclusion of Antihypertensive Agent Takers				
Total	595	286	309	
Global PSQI score	5 (3,8)	5 (3,8)	5 (3,7)	–1.91/0.028
Poor sleep quality (n,%)	285 (45.0)	135 (47.7)	124 (40.3)	3.32/0.047
Men	221	99	122	
Global PSQI score	4 (2,7)	4 (2,7)	4 (2.8,6)	–0.03/0.974
Poor sleep quality (n,%)	75 (34.2)	33 (34.0)	42 (34.4)	0.004/0.533
Women	374	187	187	
Global PSQI score	5 (3,8)	6 (4,8)	5 (3,7.3)	–2.08/0.038
Poor sleep quality (n,%)	184 (49.5)	102 (54.8)	82 (44.1)	5.30/0.024

PSQI = Pittsburgh Sleep Quality Index, UK = urinary potassium.

Table 3—Associations between 24-hour urinary potassium and sleep quality by logistic regression (OR, 95% CI, *P*).

	Unadjusted Model	Model 1	Model 2
Total			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	1.46 (1.09,1.96), *P* = .011	1.50 (1.01,2.23), *P* = .045	1.50 (1.01,2.24), *P* = .045
Men			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	1.16 (0.71,1.90), *P* = .566	1.25 (0.64,2.44), *P* = .519	1.22 (0.62,2.39), *P* = .570
Women			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	1.68 (1.11,2.34), *P* = .013	1.65 (1.00,2.70), *P* = .048	1.65 (1.01,2.71), *P* = .047
Sensitivity Analysis by Exclusion of Antihypertensive Agent Takers			
Total			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	0.74 (0.53,1.02), *P* = .069	1.56 (1.00,2.42), *P* = .047	1.56 (1.00,2.42), *P* = .047
Men			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	0.98 (0.52,1.72), *P* = .950	1.08 (0.53,2.23), *P* = .825	1.08 (0.51,2.25), *P* = .849
Women			
24-h UK ≥ 24.8 mmol/L	Ref	Ref	Ref
24-h UK < 24.8 mmol/L	1.55 (1.02,2.32), *P* = .038	1.56 (1.00,2.40), *P* = .047	1.67 (1.00,2.77), *P* = .050

Model 1 was adjusted for age, sex, education status, occupation, smoking status, alcohol assumption, systolic blood pressure, waist circumference, dyslipidemia, diabetes mellitus, estimated glomerular filtration rate, 24-hour urine Na concentration, and anxiety and depression status. Model 2 was further adjusted for sleep-disordered breathing on the basis of model 1. CI = confidence interval, OR = odds ratio, Ref = reference, UK = urinary potassium.

was assessed using a single-day sample, which may not be reflective of participants' usual dietary intake or pattern due to seasonal or daily variations in urinary potassium excretion and may bias the association of the two toward null. Fourth, urine samples were collected on weekdays and weekends, and from spring to summer, which may help decrease the interpersonal variability at population level. Fifth, data were not collected on dietary habits, which might have been changed during the sample collection period; therefore, there may have been false estimates of the real potassium intake status of the population and this may have biased the association between potassium intake and sleep quality. Sixth, this study was carried out in a specific country, and the results need to be studied further in other countries and populations.

CONCLUSIONS

These results suggest that low potassium intake, indicated by lower potassium excretion, is associated with poor sleep quality in the general population, especially among women. Therefore, additional research is necessary to clarify the effect of increasing potassium intake to improve sleep quality.

ABBREVIATIONS

BMI, body mass index
BP, blood pressure
CI, confidence interval
NoSAS score, Neck circumference Obesity, Snoring, Age, Sex score
OR, odds ratio
PSQI, Pittsburgh Sleep Quality Index
SAS, self-rating anxiety scale
SDB, sleep-disordered breathing

REFERENCES

1. Cappuccio FP, Miller MA. Sleep and cardio-metabolic disease. *Curr Cardiol Rep.* 2017;19(11):110.
2. Ricardo AC, Goh V, Chen J, et al. Association of sleep duration, symptoms, and disorders with mortality in adults with chronic kidney disease. *Kidney Int Rep.* 2017;2(5):866–873.
3. Soldatos CR, Allaert FA, Ohta T, Dikeos DG. How do individuals sleep around the world? Results from a single-day survey in ten countries. *Sleep Med.* 2005;6(1):5–13.
4. Fatima Y, Doi SA, Najman JM, Mamun AA. Exploring gender difference in sleep quality of young adults: findings from a large population study. *Clin Med Res.* 2016;14(3-4):138–144.
5. Zhu X, Hu Z, Nie Y, et al. The prevalence of poor sleep quality and associated risk factors among Chinese elderly adults in nursing homes: a cross-sectional study. *PLoS One.* 2020;15(5):e0232834.
6. Simonelli G, Marshall NS, Grillakis A, Miller CB, Hoyos CM, Glozier N. Sleep health epidemiology in low and middle-income countries: a systematic review and meta-analysis of the prevalence of poor sleep quality and sleep duration. *Sleep Health.* 2018;4(3):239–250.
7. Khandelwal D, Dutta D, Chittawar S, Kalra S. Sleep disorders in type 2 diabetes. *Indian J Endocrinol Metab.* 2017;21(5):758–761.
8. Liu RQ, Qian Z, Trevathan E, 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.
9. Kwok CS, Kontopantelis E, Kuligowski G, et al. Self-reported sleep duration and quality and cardiovascular disease and mortality: a dose-response meta-analysis. *J Am Heart Assoc.* 2018;7(15):e008552.
10. Sejbuk M, Mirończuk-Chodakowska I, Witkowska AM. Sleep Quality: A Narrative Review on Nutrition, Stimulants, and Physical Activity as Important Factors. *Nutrients*. 2022;14(9):1912.
11. Rezaei M, Khormali M, Akbarpour S, Sadeghniiat-Hagighi K, Shamsipour M. Sleep quality and its association with psychological distress and sleep hygiene: a cross-sectional study among pre-clinical medical students. *Sleep Sci.* 2018;11(4): 274–280.
12. Xie YJ, Cheung DS, Loke AY, et al. Relationships between the usage of televisions, computers, and mobile phones and the quality of sleep in a Chinese population: community-based cross-sectional study. *J Med Internet Res.* 2020; 22(7):e18095.
13. Komada Y, Narisawa H, Ueda F, et al. Relationship between Self-Reported Dietary Nutrient Intake and Self-Reported Sleep Duration among Japanese Adults. *Nutrients.* 2017;9(2):134.
14. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Sleep symptoms associated with intake of specific dietary nutrients. *J Sleep Res.* 2014;23(1):22–34.
15. Grandner MA, Jackson N, Gerstner JR, Knutson KL. Dietary nutrients associated with short and long sleep duration. Data from a nationally representative sample. *Appetite.* 2013;64:71–80.
16. Suzuki F, Morita E, Miyagi S, et al. Protein intake in inhabitants with regular exercise is associated with sleep quality: results of the Shika study. *PLoS One.* 2021;16(2):e0247926.
17. St-Onge MP, Mikic A, Pietrolungo CE. Effects of diet on sleep quality. *Adv Nutr.* 2016;7(5):938–949.
18. Wu W, Zhao A, Szeto IM, et al. Diet quality, consumption of seafood and eggs are associated with sleep quality among Chinese urban adults: a cross-sectional study in eight cities of China. *Food Sci Nutr.* 2019;7(6):2091–2102.
19. Mossavar-Rahmani Y, Jung M, Patel SR, et al. Eating behavior by sleep duration in the Hispanic Community Health Study/Study of Latinos. *Appetite.* 2015;95: 275–284.
20. Liang H, Beydoun HA, Hossain S, et al. Dietary Approaches to Stop Hypertension (DASH) score and its association with sleep quality in a national survey of middle-aged and older men and women. *Nutrients.* 2020;12(5):1510.
21. Heizhati M, Zhang Y, Shao L, et al. Decreased serum potassium may disturb sleep homeostasis in essential hypertensives. *Hypertens Res.* 2019;42(2):174–181.
22. Cirelli C, Bushey D, Hill S, et al. Reduced sleep in Drosophila Shaker mutants. *Nature.* 2005;434(7037):1087–1092.
23. Dean T, Xu R, Joiner W, Sehgal A, Hoshi T. Drosophila QVR/SSS modulates the activation and C-type inactivation kinetics of Shaker K(+) channels. *J Neurosci.* 2011;31(31):11387–11395.
24. Kim JH, Ki Y, Lee H, et al. The voltage-gated potassium channel Shaker promotes sleep via thermosensitive GABA transmission. *Commun Biol.* 2020;3(1):174.
25. Huang Y, Van Horn L, Tinker LF, et al. Measurement error corrected sodium and potassium intake estimation using 24-hour urinary excretion. *Hypertension.* 2014; 63(2):238–244.
26. Neal B, Wu Y, Feng X, et al. Effect of salt substitution on cardiovascular events and death. *N Engl J Med.* 2021;385(12):1067–1077.
27. Bernabe-Ortiz A, Sal Y Rosas VG, Ponce-Lucero V, et al. Effect of salt substitution on community-wide blood pressure and hypertension incidence. *Nat Med.* 2020; 26(3):374–378.
28. Tasali E, Wroblewski K, Kahn E, Kilkus J, Schoeller DA. Effect of sleep extension on objectively assessed energy intake among adults with overweight in real-life settings: a randomized clinical trial. *JAMA Intern Med.* 2022;182(4):365–374.
29. Wang Z, Li N, Heizhati M, et al. Association between 24-h urinary sodium to potassium ratio and mild cognitive impairment in community-based general population. *Public Health Nutr.* 2021;24(17):5795–5804.
30. Marti-Soler H, Hirotsu C, Marques-Vidal P, et al. The NoSAS score for screening of sleep-disordered breathing: a derivation and validation study. *Lancet Respir Med.* 2016;4(9):742–748.
31. Nerbass FB, Pecoits-Filho R, McIntyre NJ, McIntyre CW, Taal MW. Development of a formula for estimation of sodium intake from spot urine in people with chronic kidney disease. *Nephron Clin Pract.* 2014;128(1-2):61–66.

32. Mohammadifard N, Khosravi A, Salas-Salvadó J, et al. Trend of salt intake measured by 24-hour urine collection samples among Iranian adults population between 1998 and 2013: the Isfahan salt study. *Nutr Metab Cardiovasc Dis.* 2019;29(12):1323–1329.
33. Mollayeva T, Thurairajah P, Burton K, Mollayeva S, Shapiro CM, Colantonio A. The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: a systematic review and meta-analysis. *Sleep Med Rev.* 2016;25:52–73.
34. Gabrys JB, Peters K. Reliability, discriminant and predictive validity of the Zung Self-rating Depression Scale. *Psychol Rep.* 1985;57(3_suppl):1091–1096.
35. Iacovides S, Avidon I, Bentley A, Baker FC. Diclofenac potassium restores objective and subjective measures of sleep quality in women with primary dysmenorrhea. *Sleep.* 2009;32(8):1019–1026.
36. Land MA, Webster J, Christoforou A, et al. The association of knowledge, attitudes and behaviours related to salt with 24-hour urinary sodium excretion. *Int J Behav Nutr Phys Act.* 2014;11(1):47.
37. Cobiac LJ, Vos T, Veerman JL. Cost-effectiveness of interventions to reduce dietary salt intake. *Heart.* 2010;96(23):1920–1925.
38. Sato-Mito N, Sasaki S, Murakami K, et al; Freshmen in Dietetic Courses Study II group. The midpoint of sleep is associated with dietary intake and dietary behavior among young Japanese women. *Sleep Med.* 2011;12(3):289–294.
39. Gonsalvez I, Li JJ, Stevens C, Chen JA, Liu CH. Preexisting depression and daytime sleepiness in women and men. *Behav Sleep Med.* 2022:20(4):380–392.
40. Barker JM, Torregrossa MM, Arnold AP, Taylor JR. Dissociation of genetic and hormonal influences on sex differences in alcoholism-related behaviors. *J Neurosci.* 2010;30(27):9140–9144.
41. Rong Y, Wang S, Wang H, et al. Validation of the NoSAS score for the screening of sleep-disordered breathing in a sleep clinic. *Can Respir J.* 2020;2020:4936423.
42. Peng M, Chen R, Cheng J, Li J, Liu W, Hong C. Application value of the NoSAS score for screening sleep-disordered breathing. *J Thorac Dis.* 2018;10(8): 4774–4781.
43. Hong C, Chen R, Qing S, et al. Validation of the NoSAS score for the screening of sleep-disordered breathing: a hospital-based retrospective study in China. *J Clin Sleep Med.* 2018;14(2):191–197.

ACKNOWLEDGMENTS

The authors thank all the participants for providing samples and data. The authors thank the community workers of Emin County for providing assistance.

SUBMISSION & CORRESPONDENCE INFORMATION

Submitted for publication October 1, 2021
Submitted in final revised form June 21, 2022
Accepted for publication June 23, 2022
Address correspondence to: Nanfang Li, MS and Mulalibieke Heizhati, PhD, No 91 Tianchi Road, Urumqi, China 830001; Tel: +86 (0991)8564818; Emails: Lnanfang2016@sina.com and 1017663289@qq.com

DISCLOSURE STATEMENT

All the authors read the paper, agreed to submit, and declare no conflicts of interest. Financial support was received from Youth Program of Provincial Health Commission (WJWY-202124).