Original Paper

Sleep Duration and Chronic Kidney Disease: Analysis of the National Health Interview Survey

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Key Words

Chronic kidney disease · Sleep duration · Race/ethnicity

Abstract

Background: Patients with chronic kidney disease (CKD) have a high prevalence of sleep disorders. The association between sleep duration and self-reported CKD was examined in a population of Americans who participated in a national survey over a 3-year period. **Study Design:** A cross-sectional study using survey data from the National Health Interview Survey (NHIS) from the year 2004–2006 was carried out. A retrospective examination of data from a community-based survey of 128,486 noninstitutionalized US civilian residents over the age of 18 years was conducted. Self-reported CKD was defined as having ‘weak or failing kidneys’. The sleep duration was defined by a self-reported estimate of habitual sleep duration. **Results:** The prevalence of participants self-reporting kidney disease was higher in those with short (≤ 6 h per night) and long (≥ 8 h per night) sleep durations when compared to those sleeping 7 h per night. Self-reported information about sleep, demographic information, and information on comorbidities were assessed using standardized validated questionnaires which reported no kidney disease. A multivariate logistic regression analysis showed increased odds of self-reported kidney disease in study participants with both short and long sleep durations compared to healthy sleepers (sleeping >7 – 8 h per night). Observational data do not permit examination of causality, although possible confounders in observations of interest can be adjusted. **Conclusion:** Among Americans surveyed in the NHIS (2004–2006), those with short or long sleep duration had higher odds of reporting that they had CKD.

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Introduction

There is increasing evidence indicating that habitual sleep duration affects morbidity and mortality. In large observational studies, both short and long sleep durations have been associated with an increased risk of hypertension [1, 2], type 2 diabetes [2, 3], obesity [2, 4], cardiovascular disease [2, 5], and all-cause mortality [6].

Chronic kidney disease (CKD) affects an estimated 10–13% of noninstitutionalized adults in the United States [7] and has serious implications for public health. A high prevalence of sleep apnea, restless leg syndrome, and overall poor sleep quality has been reported in patients with CKD [8–12]. The majority of studies that examined sleep health in CKD had a small sample size and focused on patients with advanced disease requiring renal replacement therapy. More recently, however, large observational studies have identified an association between predialysis CKD and sleep apnea or other indices of poor sleep quality [13, 14].

While there is a growing body of evidence that sleep disorders are common in patients with CKD, the question of whether sleep duration is independently associated with CKD has not been extensively studied. It is critical to answer this question for several reasons: first, sleep duration has been associated with conditions that lead to CKD as noted above; second, sleep duration is a potentially modifiable factor, and third, short sleep duration has been associated with proteinuria [15], a key prognostic factor of CKD. In this study, we used data from the National Health Interview Survey (NHIS) to examine whether there is an association between inadequate sleep duration and self-reported CKD.

Methods

Study Design

The NHIS is a cross-sectional interview survey conducted annually by the National Center for Health Statistics at the Centers for Disease Control and Prevention. The survey employs a multistage probability design to select representative samples of the civilian, noninstitutionalized population of the United States. In addition to household information, trained interviewers collect individual data on sociodemographic factors, overall health status, health behavior, health care access and utilization, and the history of chronic conditions from a randomly selected adult member of a household. The questionnaire is administered using computer-assisted personal interviewing, which enables data validation through rules embedded in the software system. Details about the design and conduct of the NHIS have been published previously [16]. This analysis is limited to subjects older than 18 years of age who participated in surveys conducted between 2004 and 2006 and had a valid response to the question: ‘During the past 12 months, have you been told by a doctor or other health professional that you had weak or failing kidneys?’ The beginning of the study period corresponds to the year when habitual sleep duration was included as a routine item in the Adult Sample Core questions.

Definitions

CKD and Sleep Duration

CKD was defined as a response of ‘yes’ to the question of whether the subject had ‘weak or failing kidneys’ diagnosed by a physician or other health care provider in the 12 months preceding the interview. The habitual sleep duration in the NHIS was recorded in full hour units. Short and long sleep durations were defined as a sleep duration of 6 h or less and 8 h or longer, respectively. A sleep duration of 7 h was used as the reference. This categorization scheme is consistent with the results of a prospective study by Kripke et al. [17] in which a sleep duration of 7 h was associated with the lowest risk of mortality.

Other Covariates

Predictor variables were selected a priori based on known associations with CKD or sleep disorders in the extant literature and consensus opinion of content experts amongst the investigators [1–5]. Self-reported chronic diseases were identified by the answers of ‘yes’ to the question ‘Have you ever been told by a doctor or other health professional that you have [disease or condition]?’ Obesity was defined as body mass index

Table 1. Comparison of sociodemographic and health characteristics of Americans participating in the 2004–2006 NHIS

Variables	CKD (2,480)	No CKD (125,999)	p value
Age (mean ± SE), years	59.6±0.7	47±0.2	0.002
Females	58.2	55	0.006
Income, USD >35,000	35.5	59.2	<0.001
BMI			<0.001
Overweight: 25–29.9	32.3	35.5	
Obese: ≥30	36.7	28.2	
Education (completed high school)	67.7	84.2	<0.001
Smoker	54.5	43.2	<0.001
Current alcohol use	68.8	76.4	<0.001
Cancer	21.1	7.7	<0.001
Coronary heart disease	22.6	4.5	<0.001
Diabetes	34.2	8.4	<0.001
Emphysema	7.7	1.9	<0.001
Heart attack	17.9	3.4	<0.001
Hypertension	68	27.2	<0.001
Stroke	15.9	2.6	<0.001
Visual problems	31.4	9.5	<0.001
Psychological distress	11.5	2.5	<0.001
Difficulty walking 1/4 mile	60.9	16.5	<0.001
Black	15.4	12.1	<0.001
Sleep duration			<0.001
Reference (7 h)	16.6	30.7	
Short sleepers (≤6 h)	36.2	40.1	
Long sleepers (≥8 h)	40.1	47.2	
Variables represent percentages unless otherwise specified.			

(BMI) of 30 or higher; volunteers with a BMI 25–29.9 were grouped as overweight. Categories of annual income, educational attainment, smoking, and alcohol use were collapsed into dichotomous values as follows: annual income USD >35,000 or USD ≤35,000; completion versus noncompletion of high school; ‘yes’ versus ‘no’ response to ever smoking 100 cigarettes in lifetime, and current use of alcohol versus no current alcohol use. A racial comparison was made between Blacks and all other races. Psychological distress was assessed by a score computed from the K6 scale, a validated measure of mental health that has been included in the NHIS questionnaires since 1997; a score of 13 or higher defined the presence of psychological distress as previously reported [18]. Individuals who responded ‘yes’ to the question ‘Do you have any trouble seeing, even when wearing glasses or contact lenses?’ were identified as having visual problems. Functional limitation due to health problems was assessed by a ‘yes/no’ response to the difficulty walking 1/4 of a mile without assistive devices.

Statistical Analysis

Participants with and without self-reported CKD were compared using the Rao-Scott χ^2 or t test for categorical and continuous variables, respectively. Unadjusted and adjusted odds ratios were calculated using multiple logistic regression, with adjustment for covariates that were selected a priori as described above and prespecified interaction terms between diabetes status and visual problems, and smoking and emphysema. The variance was estimated with Taylor series linearization. The person-level NHIS sample weights were divided by the number of years in the pooled dataset to accurately reflect the total population the pooled sample represents. Statistical significance was considered at two-tailed $\alpha < 0.05$. Statistical analysis was performed with SAS 9.3 (SAS Institute, Cary, N.C., USA) using the appropriate SURVEY procedures for complex sampling.

Fig. 1. Predictors of CKD among participants surveyed in the 2004–2006 NHIS. CAD = Coronary artery disease; 3BL = 3 blocks.

Results

Table 1 describes the characteristics of the NHIS participants. The prevalence of cardiovascular comorbidities was significantly higher in individuals self-reporting kidney disease. Of particular interest are reports of hypertension, coronary heart disease, diabetes, myocardial infarction/heart attack, and cerebrovascular accidents/stroke. There was also a higher prevalence of CKD among respondents with cancer, emphysema, visual problems, psychological stress, and difficulty walking 1/4 of a mile. Another interesting observation is the fact that participants who self-reported CKD were less likely to have completed high school education and also more likely to be earning USD ≤35,000. Female sex was a significant contributor to self-reported CKD. A significant number of Blacks were also found to be reporting CKD.

There was a higher prevalence of CKD among participants reporting short sleep (≤6 h per night) and long sleep (≥8 h per night) durations compared with healthy sleep durations (7 h per night). As shown in figure 1, after multivariate adjustment, participants reporting long sleep duration (≥8 h per night) also had an almost 2-fold odds ratio for reporting that they were diagnosed with CKD compared to participants with healthy sleep duration (7 h per night). Figure 1 also shows that participants with short sleep duration (≤6 h per night) had >2-fold increased odds for self-reported CKD compared to participants with healthy sleep.

Discussion

This study showed that (1) study participants with a short habitual sleep duration had >2-fold odds of self-reported CKD compared to healthy sleepers and (2) study participants with habitual long sleep duration had almost 2-fold increased odds of self-reporting that they were given the diagnosis of CKD. It also showed that race/ethnicity may not be contributing significantly to this association between sleep duration and self-reported CKD.

To our knowledge, this is one of the first population-based studies to find a strong association between extremes of sleep duration and CKD. Our results extend the findings of the limited number of population-based studies on the topic. In a study of the relationship of race with physical and psychological well-being, Kutner et al. [19] reported that the prevalence of restless sleep was higher among community-dwelling dialysis patients than among their nondialysis counterparts. The main focus of the study, however, was the interplay of race, physical disease burden, and psychosocial well-being, and as such, the study did not specifically report differences in sleep duration.

A more recent study by Plantinga et al. [14] examined the association of sleep-related problems with CKD using data from the National Health and Nutrition Examination Survey (NHANES). The study participants were grouped into 3 categories based on the estimated glomerular filtration rate (eGFR): no CKD (eGFR >90 ml/min), stage 1 and 2 CKD (eGFR ≥60 ml/min and proteinuria), and stage 3 and 4 CKD (eGFR 15–59 ml/min). The study found that the sleep disorders and the use of sleep medications were more common among individuals with CKD but the relationship of sleep duration with CKD was not uniform across all stages of CKD. The adjusted odds of inadequate sleep (≤6 h) were not different between subjects with stage 1 and 2 CKD and those with no CKD. Subjects with stage 3 and 4 CKD, however, had lower adjusted odds of inadequate sleep as compared to those without CKD. The authors attributed this paradoxical finding to the higher use of sleep medications observed among those with CKD. Finally, Yamamoto et al. [15] retrospectively analyzed data on employees of the Osaka University in Japan to identify predictors of proteinuria. A short sleep duration was identified as an independent risk factor for proteinuria. Furthermore, there was a graded increase in the risk of proteinuria as sleep duration decreases.

The cross-sectional design of our study does not permit causal inferences. Although the direct renal effects of aberrant sleep duration have not been extensively investigated, emerging evidence suggests that sleep deprivation could interfere with normal renal physiology. Acute sleep deprivation in humans reduces plasma renin, angiotensin, and aldosterone levels, and is associated with increased urinary excretion of sodium and potassium [20, 21]. In addition, the normal nocturnal dipping of blood pressure is attenuated. Similarly, animal studies of acute sleep deprivation have shown increased renal sympathetic nerve activity and reduced plasma angiotensin II levels; mean arterial pressure remained unchanged [22]. Taken together, these observations suggest that the changes in the renin-angiotensin-aldosterone system and solute excretion are most likely hormonal and renal adaptations to blunt the hypertensive response of renal sympathetic hyperactivity. Sustained disruption of the circadian rhythm may have more permanent consequences, as observed in hamsters with a mutation of the circadian regulatory gene casein kinase-1 ϵ [23]. Animals heterozygote for the mutation exhibit phase-advanced and shortened circadian rhythms and were shown to develop proteinuria, renal tubular atrophy, and cardiac dysfunction.

As mentioned above, several studies have described an association of aberrant sleep duration with hypertension, diabetes, and cardiovascular disease, conditions that frequently accompany or cause CKD [1–5]. Our data demonstrate an association between sleep duration and CKD that is independent of these conditions. It is, therefore, possible that CKD and aberrant sleep duration share common pathophysiologic mechanisms. Indeed, both short and long

sleep durations have been associated with markers of inflammation, a process now recognized to play an important role in the pathophysiology of chronic conditions such as diabetes, hypertension, and cardiovascular disease [24–30]. Sleep deprivation may also activate endothelin, a powerful vasoconstrictor involved in the pathogenesis of hypertension [31].

Once CKD is established, the uremic environment would further disturb the circadian rhythm, manifesting with more severe sleep disorders such as sleep apnea or periodic limb movement disorder. In addition to the clinical associations with these sleep disorders, advanced CKD has been linked to the suppression of the melatonin surge that is integrally linked to the regulation of the circadian rhythm [32, 33]. Further evidence that advanced CKD exacerbates sleep disturbance is the observation that kidney transplantation and long nocturnal hemodialysis partially correct sleep apnea in dialysis patients [34–36].

The results of our study should be interpreted with several limitations in mind. First, both sleep duration and the presence or absence of any clinical condition including CKD was self-reported, which could lead to recall bias and misclassification of the disease status. Since individuals were asked to provide a subjective report of habitual sleep duration, data might have been influenced by recall/response bias, which is often observed in epidemiologic studies. These may on occasion be affected by the educational status. Although we did not specifically ascertain potential recall/response bias, our regression model adjusted for educational status. Second, our measure of depression was calculated from the limited data available in the survey. Third, even though we have adjusted for several variables that could explain the relationship between CKD and sleep duration, it is possible that our analysis has not accounted for other factors not captured in the survey.

Our study also has a number of strengths. Its findings are based on a large, nationally representative sample of adults. The NHIS is a rich data source, and standardized training of interviewers and the checks used in the computerized data collection system allow for the collection of highly accurate information. We minimized the likelihood of a spurious association by validating our findings in a training dataset on a separate cohort. Finally, we used a validated score to assess depression employing available survey data.

Sleep is an extremely important part of our daily lives. The finding of increased odds of self-reported CKD in Americans with aberrant sleep duration is a very important observation with major public health implications. Clinicians should, therefore, consider routinely assessing sleep complaints, and investigations into possible mechanisms underlying this association need to be pursued in the future.

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