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Original Contribution

Correlates of Short and Long Sleep Duration: A Cross-Cultural Comparison Between the United Kingdom and the United States

The Whitehall II Study and the Western New York Health Study

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The authors examined sociodemographic, lifestyle, and comorbidity factors that could confound or mediate U-shaped associations between sleep duration and health in 6,472 United Kingdom adults from the Whitehall II Study (1997–1999) and 3,027 US adults from the Western New York Health Study (1996–2001). Cross-sectional associations between short (<6 hours) and long (>8 hours) durations of sleep across several correlates were calculated as multivariable odds ratios. For short sleep duration, there were significant, consistent associations in both samples for unmarried status (United Kingdom: adjusted odds ratio (AOR) = 1.49, 95% confidence interval (CI): 1.15, 1.94; United States: AOR = 1.49, 95% CI: 1.10, 2.02), body mass index (AORs were 1.04 (95% CI: 1.01, 1.07) and 1.02 (95% CI: 1.00, 1.05)), and Short Form-36 physical (AORs were 0.96 (95% CI: 0.95, 0.98) and 0.97 (95% CI: 0.96, 0.98)) and mental (AORs were 0.95 (95% CI: 0.94, 0.96) and 0.98 (95% CI: 0.96, 0.99)) scores. For long sleep duration, there were fewer significant associations: age among men (AORs were 1.08 (95% CI: 1.01, 1.14) and 1.05 (95% CI: 1.02, 1.08)), low physical activity (AORs were 1.75 (95% CI: 0.97, 3.14) and 1.60 (95% CI: 1.09, 2.34)), and Short Form-36 physical score (AORs were 0.96 (95% CI: 0.93, 0.99) and 0.97 (95% CI: 0.95, 0.99)). Being unmarried, being overweight, and having poor general health are associated with short sleep and may contribute to observed disease associations. Long sleep may represent an epiphenomenon of comorbidity.

comorbidity; confounding factors (epidemiology); cross-cultural comparison; life style; sleep

Abbreviations: SF-36, Short Form-36; UK, United Kingdom.

Editor's note*: An invited commentary on this article appears on page 1365.*

Observational epidemiologic studies suggest that both short and long durations of sleep may be associated with an increased risk of adverse health outcomes, such as total mortality, cardiovascular disease, type 2 diabetes mellitus, obesity, respiratory disorders, and poor general health (1–12). These findings have often shown a U-shaped association between sleep duration and health (13). However, there are a number of unresolved issues regarding the nature of this association. For example, it is possible that both short and long sleep durations may identify persons who are at high risk for several medical conditions; these population subgroups are likely to be characterized by a distinctive pattern of sociodemographic, lifestyle, and comorbid medical conditions (14) that may confound associations or increase the likelihood of reverse causality and bidirectional relations (15). Altogether, given these unresolved issues and the lack of specificity of the observed associations, it is

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possible that short/long sleeping may represent a risk marker for poorer health outcomes rather than a casual risk factor for diseases.

Sleep habits in the general population are the result of a complex interaction between different kinds of factors (e.g., social, behavioral, psychological, comorbid conditions). Cross-cultural comparisons play an important role in understanding disease etiology, especially in the study of exposures of a multifaceted nature, such as sleep habits. A few studies have attempted to address this issue; however, they have been based on highly selected populations or have focused on a restricted number of potential correlates (16–21). To our knowledge, none have made cross-cultural comparisons.

The present study, a study of correlates of sleep duration in 2 populations from 2 different countries and social settings, may further our understanding of the complex interplay between sleep and health and may provide some insights into possible underlying mechanisms. In relation to previous literature, novel features of the present study are the inclusion of physical and mental health functioning scales and the use of multivariate analyses. Specifically, we examined a number of sociodemographic variables, lifestyle behaviors, measures of general health, and comorbid conditions that may confound or mediate the observed associations of short and long sleep duration with health outcomes. In order to reinforce the external validity and generalizability of the findings derived from this analysis, we performed a cross-cultural comparison of sleep correlates using samples from 2 large, well-characterized population-based studies: the Whitehall II Study (n = 6,472), from the United Kingdom, and the Western New York Health Study (n = 3,027), from the United States.

MATERIALS AND METHODS

Study populations

The Whitehall II Study cohort was recruited in 1985–1988 (phase 1) from 20 civil service departments based in London, United Kingdom. The rationale, design, and methods of the study have been described in detail elsewhere (22). Briefly, the study was set up to determine the pathways underlying the social differences in health that were apparent in the original Whitehall Study (23), and it was specifically designed to focus on pathways not originally examined, such as psychosocial and dietary factors. The initial response rate was 73%, and the final cohort consisted of 10,308 participants (3,413 women and 6,895 men). Follow-up screening examinations took place in 1991–1993 (phase 3), 1997–1999 (phase 5), and 2003–2004 (phase 7), whereas postal questionnaires were sent to participants in 1989 (phase 2), 1995 (phase 4), and 2001 (phase 6). The participation rates of the original cohort (n = 10,308) were 83%, 76%, and 68% in phases 3, 5, and 7, respectively. In this report, we used data from phase 5. The total sample in phase 5 consisted of 7,204 participants, after exclusion of those who did not provide complete data (n = 630). Given the low numbers of participants from other ethnic groups (n = 612), the present analyses were restricted to the 6,472 white persons (28.3% women) aged 45–69 years (median, 55 years) who had complete sleep data for phase 5.

The US participants in this report were originally enrolled as healthy control participants in the Western New York Health Study. The Western New York Health Study was actually a series of case-control studies designed to examine the complex relations between alcohol drinking patterns and chronic disease risk, as described in detail elsewhere (24). Potential controls were required to be a resident of Erie County or Niagara County, New York, aged 35–79 years with no history of cancer. Potential participants were identified through 2 sources: 1) the New York State Department of Motor Vehicles, for participants aged 35–64 years (95% of New York residents in this age group have a driver's license), and 2) Health Care Financing Administration lists, for participants aged 65–79 years (these lists include virtually all persons in the age range of interest). Between 1996 and 2001, a total of 6,837 potential participants were identified, contacted, and deemed eligible for the study. Of these, 4,065 agreed to participate and were examined, for a participation rate of 59.5%. For the present analyses, participants from ethnic groups other than white were excluded (n = 381), as well as those with missing sleep data (n = 657). The remaining 3,027 participants (56.5% women), aged 35–79 years (median, 56 years), were included in this study.

Sleep duration

In phase 5 of the Whitehall II Study, sleep duration was elicited by posing the question, "How many hours of sleep do you have on an average weeknight?" Response categories were 5 hours or less, 6 hours, 7 hours, 8 hours, and 9 hours or more.

In the Western New York Health Study, sleep duration in the past week was ascertained with the Seven-Day Physical Activity Recall questionnaire (25) by posing the question, "On the average, how many hours did you sleep each night during the last 5 weekday nights (Sunday–Thursday)?" In order to create comparable categories of sleep duration between the 2 samples, response categories were collapsed into 3 main groups: short sleep duration (<6 hours), normal sleep duration (6–8 hours), and long sleep duration (>8 hours). This classification is consistent with the classifications used in the majority of previous studies on the health effects of habitual sleep duration (1–12).

Correlates

Correlations were examined for the following factors: marital status, socioeconomic status, body mass index, waist circumference, smoking habits (cigarettes, cigars, or pipes), alcohol drinking, physical activity, Short Form-36 (SF-36) physical and mental health scores (26), depressive symptoms, hypertension, and diabetes.

In order to facilitate comparison between the 2 samples, we categorized the variables as follows. Marital status was categorized as married or unmarried. As a proxy measure of current or recent socioeconomic status, in the Whitehall II Study, employment grade was used, as determined from the participant's last known civil service grade (19% had retired by phase 5), and was divided into 3 categories in order of decreasing salary: administrative, professional/executive, and clerical/support. In the Western New York Health Study, annual household income was used and was divided into 3 categories in order of decreasing income: >$70,000, $30,000–70,000, and <$30,000. In both samples, several anthropometric measurements were made, including height, weight, and waist circumference. Body mass index was calculated as weight (kg)/height (m)^2 and was divided into 3 categories: <25, 25–29.9, and ≥30. Waist circumference was divided into tertiles based on the sample-specific distribution.

In both samples, smoking status was divided into 2 categories: current smoker/non-current smoker. Current alcohol consumption was recorded for either the previous week (Whitehall II Study) or the previous 30 days (Western New York Health Study). Drinking status was divided into 2 categories: current drinker/non-current drinker. For physical activity, in the Whitehall II Study participants were asked to indicate the number of occasions and hours they had spent engaging in a series of specific activities over the past 4 weeks. These activities were classified into light, moderate, or vigorous activities on the basis of their energy expenditure (metabolic equivalents). In this analysis, leisure-time physical activity was categorized by energy use in 2 categories: "high vigorous" activity (subjects who reported at least 1.5 hours of vigorous activity per week) and "low vigorous" activity (subjects who reported no vigorous activity or less than 1.5 hours of vigorous activity per week). In the Western New York Health Study, current physical activity in the past week was ascertained with the Seven-Day Physical Activity Recall questionnaire used in the Stanford Five-City Project (25); for comparability purposes, US participants were divided at the median (high/low physical activity) on the basis of their energy expenditure (metabolic equivalents).

In both samples, general health status was assessed using the physical and mental health component summaries of the SF-36 health survey questionnaire (26). These summary measures are standardized as *t* scores and have higher reliability than the individual scales. Participants were divided at the median (high/low scores) on the basis of the sample-specific distribution. In the Whitehall II Study, psychiatric morbidity, including depressive symptoms, was assessed with a modified General Health Questionnaire score. In the Western New York Health Study, the presence of depressive symptoms was assessed using the Center for Epidemiologic Studies Depression Scale (27); participants were divided into 2 groups based on the cutpoint for major depressive symptoms (score ≥22).

In both samples, blood pressure was measured 3 times in the sitting position by trained and certified technicians using a standard mercury sphygmomanometer. The onsets of the first-phase (systolic) and fifth-phase (diastolic) Korotkoff sounds were recorded. The mean of the second and third measurements was used in the analyses. Hypertension was defined as blood pressure ≥140/90 mm Hg or regular use of antihypertensive medication. In both samples, fasting glucose concentrations were determined by means of glucose oxidase methods. Diabetes was defined either as a fasting glucose concentration ≥126 mg/dL (≥7.0 mmol/L) or use of antidiabetic medication.

Ethical approval

Ethical approvals were obtained from the University College London Medical School committee on the ethics of human research for the Whitehall II Study and from the University at Buffalo (State University of New York) institutional review board for the Western New York Health Study.

Statistical analysis

For continuous and categorical variables, respectively, Kruskal-Wallis and χ^2 tests were used to determine the statistical significance of any difference in the distributions of the selected correlates across categories of sleep duration (<6 hours, 6–8 hours, and >8 hours) in each sample. Two sets of logistic regression analyses were performed to calculate age- and sex-adjusted odds ratios (reduced models) for both short (<6 hours) and long (>8 hours) durations of sleep, as compared with a normal duration of sleep (6–8 hours), across the selected correlates in each sample. To examine whether the association of each correlate of short and long sleep duration differed between men and women, we performed tests for interaction between sex and each of the selected correlates; results are displayed in the tables. Multivariable logistic regression analyses were performed with the inclusion of all correlates (fully adjusted models) for both short and long durations of sleep in each sample separately. Separate effects were estimated in men and women when the sex × correlate interaction terms were statistically significant. All analyses were carried out using STATA software, version 9.0 (Stata Corporation, College Station, Texas).

RESULTS

Characteristics of participants are reported in Table 1. The 2 populations were comparable with regard to several of the selected variables. For example, mean age, percentage of unmarried persons, mean SF-36 physical and mental scores, presence of depressive symptoms, mean blood pressure, and prevalence of hypertension were similar between the 2 samples. On the other hand, the age range and the prevalence of women were much greater in the Western New York Health Study. The US sample was also characterized by higher mean values for anthropometric measures, greater prevalences of current smokers and diabetics, and a lower prevalence of current drinkers and a lower mean daily volume of alcohol consumption (among current drinkers). For sleep duration, while in both samples the majority of participants fell into the normal-range category (6–8 hours), the percentages of short- and long-duration sleepers were greater in the US sample.

Selected characteristics of participants across categories of sleep duration are reported in Table 2. For both samples, there were significant, consistent associations for several potential correlates of sleep duration. For example, the percentages of unmarried persons, persons in the lowest

Table 1. Baseline Characteristics[a] of 2 Populations From the Whitehall II Study (London, United Kingdom; 1997–1999) and the Western New York Health Study (Buffalo, New York; 1996–2001)

Variable	Whitehall II Study (n = 6,472)	Western New York Health Study (n = 3,027)
Age, years	55.8 (6.1)	56.4 (11.5)
Women, %	28.3	56.5
Unmarried (vs. married), %	21.4	23.7
Lowest socioeconomic status[b], %	11.4	29.6
Sleep duration, %		
<6 hours	7.5	13.7
6–8 hours	91.1	80.6
>8 hours	1.4	5.7
Body mass index[c]	26.1 (3.9)	28.1 (5.7)
Waist circumference, cm	88.7 (11.8)	91.6 (14.9)
Current smoker, %	10.7	15.3
Current alcohol drinker, %	86.0	68.3
Daily alcohol consumption[d], units[e]	2.4 (2.2)	0.9 (1.7)
Low (vs. high) physical activity, %	55.9	50.1
Short Form-36 score		
Physical	51.2 (8.0)	49.4 (8.9)
Mental	51.1 (9.4)	53.0 (8.2)
Depressive symptoms, %	12.4	9.1
Systolic blood pressure, mm Hg	122.9 (16.3)	120.8 (16.2)
Diastolic blood pressure, mm Hg	77.5 (10.6)	73.2 (9.8)
Hypertension[f], %	29.2	31.6
Diabetes mellitus[g], %	2.5	8.0

[a] Data are expressed as mean (standard deviation) or percentage.
[b] Based on the lowest employment grade in the Whitehall II Study and the lowest annual household income in the Western New York Health Study.
[c] Weight (kg)/height (m)^2.
[d] Computed among current drinkers only.
[e] In the Whitehall II Study, 1 alcohol unit was defined as approximately 8 g of ethanol. In the Western New York Health Study, 1 alcohol unit was defined as a standard drink, which contains approximately 12 g of ethanol.
[f] Defined as blood pressure ≥140/90 mm Hg or regular use of antihypertensive medication.
[g] Defined as fasting glucose concentration ≥126 mg/dL (≥7.0 mmol/L) or use of antidiabetic medication.

socioeconomic status group, current smokers, persons with low physical activity, and persons with depressive symptoms, hypertension, and diabetes (the latter in the United Kingdom (UK) sample only) were significantly higher among either short- or long-duration sleepers than among persons in the midrange category, whereas the percentages of current drinkers were higher in the latter category. Likewise, higher mean values for anthropometric measures and lower SF-36 scores were found in the 2 extreme categories of sleep duration. Interestingly, the mean age of participants tended to increase across categories of sleep duration (significantly in the US sample).

Table 3 shows the age- and sex-adjusted odds ratios for a short duration of sleep (<6 hours), as compared with a normal duration of sleep (6–8 hours), across the selected correlates in each sample. There were significant, consistent associations between several correlates and a higher likelihood of short sleeping across the 2 study populations. In addition, there was a significant sex × age interaction in the US sample and a significantly lower likelihood of short sleeping in the older age groups among male participants. Moreover, in the US sample, there was a significant sex × hypertension interaction, with a significant association being observed only among women (odds ratio = 1.80, 95% confidence interval: 1.32, 2.47). Findings for low physical activity were inconsistent between the 2 samples. Diabetes was associated with a significantly higher likelihood of short sleep duration in the UK sample only.

Table 4 displays the age- and sex-adjusted odds ratios for a long duration of sleep (>8 hours), as compared with a normal duration of sleep (6–8 hours), across the selected correlates in each sample. In both samples, the likelihood of being a long-duration sleeper significantly increased with age in male participants and in females in the US sample, with significant sex × age interactions. Moreover, only a few variables were significantly associated with a higher likelihood of long-duration sleep: low physical activity in both studies, current smoking in the Western New York Health Study, and low (less than median) SF-36 physical score in the Western New York Health Study. For other correlates (socioeconomic status, waist circumference, current alcohol drinking, depressive symptoms, and diabetes), the point estimates were in the expected direction but did not reach a formal level of statistical significance—probably a result of the small numbers of long-duration sleepers in both samples (n = 93 in the Whitehall II Study; n = 173 in the Western New York Health Study).

In multivariable logistic regression analyses (Table 5), being unmarried, increasing body mass index (as a continuous variable), and hypertension among women were positively associated with short duration of sleep, while SF-36 physical and mental scores (as continuous variables) were negatively associated. Moreover, low socioeconomic status and diabetes remained significant correlates in the UK sample, whereas current smoking remained a significant correlate in the US sample. Older age (in men) and low physical activity were positively associated with long duration of sleep, while SF-36 physical score (and mental score in the UK sample) were negatively associated.

DISCUSSION

To our knowledge, this is the first study to provide cross-cultural comparisons of correlates of both short and long durations of sleep using 2 large, well-characterized populations from 2 different countries. In the present study, we attempted to provide a comprehensive analysis of potential determinants of sleep duration, which for the first time

Table 2. Baseline Characteristics[a] of Participants by Category of Sleep Duration, Whitehall II Study (London, United Kingdom; 1997–1999) and Western New York Health Study (Buffalo, New York; 1996–2001)

Variable	Sleep Duration (Hours)			*P* Value[b]
	<6	6–8	>8	
Whitehall II Study ($n = 6,472$)				
No. of subjects	486	5,893	93	
Age, years	55.6 (5.8)	55.8 (6.1)	56.9 (5.7)	0.14
Women, %	39.1	27.1	43.0	<0.001
Unmarried (vs. married), %	34.4	20.3	26.4	<0.001
Lowest socioeconomic status, %	19.1	10.7	20.4	<0.001
Body mass index[c]	27.1 (4.8)	26.0 (3.8)	25.8 (3.9)	<0.001
Waist circumference, cm	90.2 (14.0)	88.6 (11.6)	87.4 (11.1)	<0.001
Current smoker, %	13.3	10.5	8.6	0.13
Current alcohol drinker, %	79.2	86.7	79.1	<0.001
Low (vs. high) physical activity, %	67.3	54.7	71.0	<0.001
Short Form-36 score				
Physical (range, 8.4–69.6)	48.1 (10.9)	51.5 (7.6)	48.3 (9.8)	<0.001
Mental (range, 2.5–73.0)	45.3 (12.9)	51.6 (8.9)	50.4 (11.8)	<0.001
Depressive symptoms, %	28.1	11.1	14.0	<0.001
Hypertension, %	35.3	28.7	29.9	0.016
Diabetes mellitus, %	5.7	2.2	5.3	<0.001
Western New York Health Study ($n = 3,027$)				
No. of subjects	414	2,440	173	
Age, years	55.9 (11.6)	56.2 (11.4)	60.8 (11.7)	<0.001
Women, %	53.9	57.2	53.2	0.30
Unmarried (vs. married), %	31.2	22.6	21.4	0.001
Lowest socioeconomic status, %	37.6	28.3	29.3	<0.001
Body mass index	29.2 (6.3)	27.8 (5.5)	28.3 (6.1)	<0.001
Waist circumference, cm	94.7 (15.6)	91.0 (14.7)	93.9 (15.3)	<0.001
Current smoker, %	20.8	14.2	17.9	0.002
Current alcohol drinker, %	60.4	69.8	66.3	0.001
Low (vs. high) physical activity, %	40.8	50.3	68.6	<0.001
Short Form-36 score				
Physical (range, 10.5–68.7)	47.0 (10.1)	50.1 (8.5)	46.5 (9.8)	<0.001
Mental (range, 13.7–69.7)	51.0 (9.3)	53.3 (8.0)	53.8 (7.9)	<0.001
Depressive symptoms, %	17.6	7.7	10.0	<0.001
Hypertension, %	35.5	30.3	40.5	0.004
Diabetes mellitus, %	7.6	8.0	9.0	0.85

[a] Data are expressed as mean (standard deviation) or percentage.

[b] *P* value for comparison across sleep duration categories using the chi-squared analysis for categorical variables and the Kruskal-Wallis test for continuous variables.

[c] Weight (kg)/height (m)^2.

included measures of physical and mental health functioning, and to present mutually adjusted results.

Short duration of sleep

The present study demonstrates significant, consistent associations for several correlates of short sleep duration in both samples. Previous investigations of the correlates of short sleep duration have been based on smaller samples (17) or have examined a highly selected number of potential correlates, often focusing on the role of sociodemographic variables (18–21). Consistent with previous investigations (18,19), being unmarried and having a low socioeconomic status (in the UK sample) were associated with a higher likelihood of short sleep duration. Moreover, increased body weight or central adiposity and smoking (in the US sample)

Table 3. Age- and Sex-Adjusted Odds Ratios for Short Sleep Duration (<6 Hours) Versus Normal Sleep Duration (6–8 Hours) According to Selected Correlates, Whitehall II Study (London, United Kingdom; 1997–1999) and Western New York Health Study (Buffalo, New York; 1996–2001)

Variable	Whitehall II Study (486/6,379)[a]						Western New York Health Study (414/2,854)					
	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend[b]	*P* for Interaction With Sex[c]	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex
Age[d], years												
Men												
≤50	67	991	1.00				88	451	1.00			
51–60	163	2,321	1.04	0.78, 1.40			34	276	0.58	0.38, 0.89		
>60	66	1,278	0.75	0.53, 1.07	0.09		69	509	0.65	0.46, 0.91	0.01	
Women												
≤50	30	338	1.00				73	619	1.00			
51–60	101	845	1.39	0.91, 2.14			66	429	1.36	0.95, 1.95		
>60	59	606	1.11	0.70, 1.76	0.95		84	570	1.29	0.92, 1.81	0.13	
Marital status												
Married	305	4,841	1.00				285	2,170	1.00			
Unmarried	160	1,312	1.84	1.49, 2.27	<0.001	0.43	129	679	1.58	1.25, 2.01	<0.001	0.84
Socioeconomic status												
Highest	150	2,906	1.00				62	613	1.00			
Medium	240	2,718	1.67	1.35, 2.07			182	1,284	1.56	1.14, 2.12		
Lowest	92	717	2.35	1.73, 3.18	<0.001	0.56	147	799	2.52	1.74, 3.63	<0.001	0.17
Body mass index[e]												
<25	135	2,118	1.00				108	894	1.00			
25–29.9	157	2,157	1.21	0.96, 1.54			152	1,070	1.12	0.85, 1.46		
≥30	88	682	2.12	1.59, 2.82	<0.001	0.40	144	809	1.57	1.19, 2.06	0.001	0.15
Tertile of waist circumference												
1 (lowest)	109	1,487	1.00				102	936	1.00			
2	93	1,496	1.16	0.84, 1.60			146	971	1.41	1.04, 1.90		
3 (highest)	143	1,479	1.85	1.36, 2.52	<0.001	0.69	153	868	1.79	1.31, 2.45	<0.001	0.08
Smoking status												
Non-current smoker	417	5,678	1.00				328	2,420	1.00			
Current smoker	64	680	1.22	0.93, 1.61	0.16	0.24	86	431	1.57	1.20, 2.04	0.001	0.15

Table continues

were also significant correlates of short sleep duration. These findings are consistent with a large number of cross-sectional investigations showing a link between short sleep and obesity (9,10, 28–31).

Furthermore, the consistent associations of short sleep with a poorer general health status, as measured by the physical and mental health component summaries of the SF-36, represent a novel observation. These findings indicate that effects of sleep duration on morbidity and mortality may first manifest as changes in self-reported general health status (or functioning). Finally, in the present study, hypertension (among women) and diabetes (in the UK sample) were significant correlates of short sleep. These findings are consistent with previous data from the Whitehall II Study on sex differences in the association of short sleep with cardiovascular disease, particularly the risk of hypertension (7).

In addition, these findings support the possibility that sleep deprivation may be associated with an increased risk of mortality, primarily through effects on cardiovascular disease (4). Indeed, in the UK sample, participants with prevalent cardiovascular disease other than hypertension had a higher likelihood of short sleep duration (odds ratio = 1.47, 95% confidence interval 1.15, 1.87) in the reduced model, although the point estimate was no longer significant in the fully adjusted model (data not shown). In the US sample, very few people had prevalent cardiovascular disease other than hypertension ($n = 13$; 0.4%), thus limiting the possibility of meaningful subgroup analyses. The cross-sectional association of short sleep duration with diabetes (in the UK sample) is consistent with previous epidemiologic investigations (8, 32, 33), as well as with mechanistic studies on the possible detrimental effects of sleep deprivation on glucose metabolism and appetite regulation (34–36).

Table 3. Continued

Variable	Whitehall II Study (486/6,379)						Western New York Health Study (414/2,854)					
	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex
Alcohol drinking status												
Non-current drinker	100	878	1.00				162	892	1.00			
Current drinker	380	5,440	0.65	0.51, 0.82	<0.001	0.16	247	1,936	0.63	0.51, 0.79	<0.001	0.11
Physical activity												
High	159	2,826	1.00				169	1,397	1.00			
Low	327	3,553	1.61	1.32, 1.96	<0.001	0.11	245	1,457	0.69	0.56, 0.86	0.001	0.27
Median Short Form-36 score												
Physical												
High	186	3,105	1.00				150	1,389	1.00			
Low	276	3,090	1.51	1.24, 1.84	<0.001	0.70	241	1,335	1.92	1.53, 2.40	<0.001	0.11
Mental												
High	146	3,092	1.00				149	1,357	1.00			
Low	316	3,103	2.22	1.80, 2.73	<0.001	0.40	242	1,367	1.79	1.43, 2.24	<0.001	0.28
Depressive symptoms												
No	343	5,509	1.00				304	2,332	1.00			
Yes	134	777	3.08	2.47, 3.82	<0.001	0.85	65	233	2.72	1.98, 3.73	<0.001	0.80
Hypertension												
No	279	4,105	1.00				267	1,967	1.00			
Yes	152	1,695	1.44	1.17, 1.78	0.001	0.13	147	887	1.30	1.03, 1.64	0.02	<0.001[f]
Diabetes mellitus												
No	396	5,506	1.00				365	2,495	1.00			
Yes	24	141	2.85	1.81, 4.48	<0.001	0.48	30	216	0.95	0.63, 1.42	0.79	0.83

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Number of short sleepers/number of short sleepers plus number of normal sleepers.

[b] *P* value for linear trend for nondichotomous variables.

[c] *P* value for interaction between sex and the specific correlate.

[d] Odds ratios for age are presented for men and women separately because of significant sex × age interactions.

[e] Weight (kg)/height (m)^2.

[f] There was a significant sex × hypertension interaction in the Western New York Health Study; age-adjusted odds ratios for men and women were 0.90 (95% CI: 0.63, 1.27) and 1.80 (95% CI: 1.32, 2.47), respectively.

Long duration of sleep

In the present study, only a few correlates were significant determinants of long sleep duration in both samples. This may have been due to limited statistical power, since only a few people could be defined as "long sleepers," unlike the case in a previous nationwide US survey (37), where the percentage of persons reporting more than 8 hours of sleep was 8.5%. However, the low prevalence of long sleepers in the present study populations is consistent with the figures derived from more recent surveys of healthy middle-aged persons (38), which may reflect secular changes in sleep duration.

In a recent investigation from the Whitehall II Study on the effects of changes in sleep duration on mortality risk, a decrease in sleep duration and an increase in sleep duration were associated with higher cardiovascular mortality and higher noncardiovascular mortality, respectively (4). The authors found an increased proportion of participants who reported having prolonged their hours of sleep per night between baseline and follow-up and speculated that 1 possible mechanism for the association of long sleep with increased noncardiovascular mortality could reside in cancer-related fatigue. At the present time, the mechanisms linking long duration of sleep with increased morbidity and mortality are little understood, although it has been hypothesized that psychiatric comorbidity, particularly depression, might contribute to this association (39). Indeed, in the only published investigation on correlates of long sleep duration in a large sample of middle-aged women, an investigation of women participating in Nurses' Health Study II, depression and low socioeconomic status were the strongest possible explanations for the association between long sleep duration and mortality (16). In the present study, depression and low socioeconomic status were not significantly associated with long sleep in either sample, although the point estimates in the reduced models were in the expected direction. It is possible that the instruments used to measure depression in the 2 samples (the General Health Questionnaire and the

Table 4. Age- and Sex-Adjusted Odds Ratios for Long Sleep Duration (>8 Hours) Versus Normal Sleep Duration (6–8 Hours) According to Selected Correlates, Whitehall II Study (London, United Kingdom; 1997–1999) and Western New York Health Study (Buffalo, New York; 1996–2001)

Variable	Whitehall II Study (93/5,986)[a]						Western New York Health Study (173/2,613)					
	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend[b]	*P* for Interaction With Sex[c]	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex
Age[d], years												
Men												
≤50	5	929	1.00				15	378	1.00			
51–60	22	2,180	1.88	0.71, 4.99			8	250	0.80	0.33, 1.92		
>60	26	1,238	3.96	1.52, 10.36	<0.001		58	498	3.19	1.78, 5.72	<0.001	
Women												
≤50	8	316	1.00				29	575	1.00			
51–60	19	763	0.98	0.43, 2.27			19	382	0.98	0.54, 1.78		
>60	13	560	0.92	0.37, 2.23	0.83		44	530	1.71	1.05, 2.77	0.03	
Marital status												
Married	64	4,600	1.00				136	2,021	1.00			
Unmarried	23	1,175	1.18	0.71, 1.96	0.52	0.08	37	587	0.88	0.60, 1.31	0.55	0.37
Socioeconomic status												
Highest	32	2,788	1.00				29	580	1.00			
Medium	42	2,520	1.36	0.84, 2.20			82	1,184	1.01	0.58, 1.77		
Lowest	19	644	2.29	1.11, 4.73	0.03	0.63	46	698	1.20	0.77, 1.88	0.74	0.20
Body mass index[e]												
<25	29	2,012	1.00				55	841	1.00			
25–29.9	26	2,026	0.95	0.55, 1.62			60	978	0.85	0.58, 1.25		
≥30	9	603	1.03	0.48, 2.20	0.97	0.89	51	716	1.03	0.69, 1.54	0.87	0.59
Tertile of waist circumference												
1 (lowest)	23	1,401	1.00				48	882	1.00			
2	18	1,421	0.85	0.42, 1.72			57	882	1.11	0.71, 1.73		
3 (highest)	18	1,354	1.23	0.59, 2.58	0.95	0.82	59	774	1.25	0.78, 2.02	0.29	0.95
Smoking status												
Non-current smoker	85	5,346	1.00				142	2,234	1.00			
Current smoker	8	624	0.77	0.37, 1.61	0.49	0.03[f]	31	376	1.50	0.99, 2.26	0.05	0.45

Table continues

Center for Epidemiologic Studies Depression Scale) limited the ability to adequately capture depressive symptoms. Other reasons may be limited statistical power and adjustment for the SF-36 mental health score, which was a significant correlate of long sleep duration in the UK sample.

Notwithstanding these issues, findings from the present study provide additional details with which to explain the observed associations of long sleep duration with increased mortality. In fact, despite the limited statistical power, significant, consistent associations of long sleep duration were found with age (especially among men) and poorer physical health status (as measured by the SF-36 physical scores) in both samples. These associations suggest that a larger burden of undiagnosed chronic comorbid conditions other than cardiovascular disease (e.g., cancer, neurodegenerative disease, osteomuscular conditions), which are common in the elderly, may contribute to the association between long sleep and mortality. It is therefore possible that long duration of sleep might be a consequence of, rather than a causative risk factor for, unrecognized chronic comorbidity, which in turn could explain the higher risk of mortality, particularly mortality from noncardiovascular causes, observed in many studies (1–4). Long sleep duration might represent a useful diagnostic tool for detecting other subclinical or undiagnosed mental or physical comorbidity (13).

Furthermore, the associations of long sleep duration with morbidity may be driven by lack of physical activity as an outcome or effect of infirmity and disease, whereas behavioral short sleep duration may be part of an unhealthy lifestyle, which in turn may impair general health status and predispose to morbidity.

Limitations

There were several limitations in the present study. First, the cross-sectional design did not allow us to establish

Table 4. Continued

Variable	Whitehall II Study (93/5,986)						Western New York Health Study (173/2,613)					
	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex	No. of Cases	No. of Subjects	OR	95% CI	*P* for Trend	*P* for Interaction With Sex
Alcohol drinking status												
Non-current drinker	19	797	1.00				58	788	1.00			
Current drinker	72	5,132	0.65	0.38, 1.09	0.10	0.07	114	1,803	0.88	0.63, 1.23	0.47	0.25
Physical activity												
High	27	2,694	1.00				54	1,266	1.00			
Low	66	3,292	1.83	1.16, 2.89	0.01	0.92	118	1,346	2.03	1.45, 2.84	<0.001	0.40
Median Short Form-36 score												
Physical												
High	37	2,956	1.00				57	1,296	1.00			
Low	52	2,866	1.30	0.84, 1.99	0.24	0.35	111	1,205	2.03	1.45, 2.83	<0.001	0.65
Mental												
High	50	2,996	1.00				89	1,297	1.00			
Low	39	2,826	0.88	0.57, 1.36	0.57	0.74	79	1,204	1.08	0.78, 1.49	0.64	0.17
Depressive symptoms												
No	80	5,246	1.00				135	2,163	1.00			
Yes	13	656	1.38	0.76, 2.51	0.29	0.52	15	183	1.44	0.82, 2.52	0.21	0.17
Hypertension												
No	54	3,880	1.00				103	1,803	1.00			
Yes	23	1,566	0.98	0.59, 1.62	0.94	0.68	70	810	1.25	0.90, 1.75	0.18	0.08
Diabetes mellitus												
No	71	5,181	1.00				151	2,281	1.00			
Yes	4	121	2.47	0.88, 6.91	0.09	0.99	15	201	1.02	0.58, 1.78	0.94	0.75

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] Number of long sleepers/number of long sleepers plus number of normal sleepers.
[b] *P* value for linear trend for nondichotomous variables.
[c] *P* value for interaction between sex and the specific correlate.
[d] Odds ratios for age are presented for men and women separately because of significant sex × age interactions.
[e] Weight (kg)/height (m)^2.
[f] There was a significant sex × smoking status interaction in the Whitehall II Study; age-adjusted odds ratios for men and women were 1.72 (95% CI: 0.77, 3.84) and 0.15 (95% CI: 0.02, 1.10), respectively.

causality or temporality. Second, the Whitehall population was an occupational cohort of white-collar workers, and both samples were limited to whites, which may reduce the generalizability of these findings to populations of different ethnic backgrounds. In addition, the comparison referred to 2 highly developed Western societies. Although these 2 societies differ in many important sociologic and economic dimensions that may manifest in health-related ways, both may differ appreciably from other societies/cultures in environmental factors known to influence sleep (e.g., seasonal photoperiod, temperature, exposure to a "24-hour lifestyle" via the media/Internet/economy) that might maximize "cultural" differences. Moreover, the suboptimal participation rate (59.5%) in the Western New York Health Study may leave open the possibility of selection bias. However, the consistency in the magnitude of the associations, especially for short sleep duration, strengthens the external validity and generalizability of these findings. Third, information about sleep duration was self-reported by the participants in both samples. Nevertheless, self-report assessments of sleep have been shown to be valid measures in comparison with quantitative sleep assessments made with actigraphy or polysomnography (40, 41). Finally, sleep duration was assessed at 1 point in time, and it is possible that a single measure of exposure may not fully capture the sustained effects of sleep duration over time. Changes in sleep duration over time may represent a better measure of exposure, as shown by their prospective association with cause-specific mortality (4).

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Table 5. Fully Adjusted Odds Ratios[a] for Short (<6 Hours) and Long (>8 Hours) Sleep Duration Versus Normal Sleep Duration (6–8 Hours) According to Selected Correlates, Whitehall II Study (London, United Kingdom; 1997–1999) and Western New York Health Study (Buffalo, New York; 1996–2001)

Variable	Whitehall II Study			Western New York Health Study		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Short Sleep Duration (<6 Hours)						
Age[b], years						
Men	0.98	0.96, 1.01	0.21	0.99	0.97, 1.01	0.24
Women	1.00	0.97, 1.94	0.90	1.00	0.98, 1.02	0.64
Marital status (unmarried)	1.49	1.15, 1.94	0.003	1.49	1.10, 2.02	0.01
Socioeconomic status (lowest)	2.04	1.37, 3.03	<0.001	1.22	0.87, 1.72	0.24
Body mass index[c,d]	1.04	1.01, 1.07	0.007	1.02	1.00, 1.05	0.05
Current smoker	0.95	0.66, 1.37	0.78	1.54	1.12, 2.11	0.008
Current alcohol drinker	0.96	0.69, 1.32	0.78	0.80	0.61, 1.04	0.10
Low (vs. high) physical activity	1.12	0.88, 1.43	0.35	0.60	0.46, 0.78	<0.001
Short Form-36 score[d]						
Physical	0.96	0.95, 0.98	<0.001	0.97	0.96, 0.98	<0.001
Mental	0.95	0.94, 0.96	<0.001	0.98	0.96, 0.99	0.004
Depressive symptoms (yes)	1.17	0.84, 1.64	0.35	1.32	0.86, 2.04	0.20
Hypertension (yes)[e]						
Men	0.90	0.65, 1.24	0.51	0.88	0.59, 1.31	0.53
Women	1.70	1.07, 2.70	0.02	1.70	1.13, 2.56	0.01
Diabetes mellitus (yes)	1.79	1.00, 3.20	0.05	0.67	0.40, 1.13	0.14
Long Sleep Duration (>8 Hours)						
Age[b], years						
Men	1.08	1.01, 1.14	0.02	1.05	1.02, 1.08	0.001
Women	0.95	0.88, 1.02	0.17	1.02	0.99, 1.04	0.27
Marital status (unmarried)	0.99	0.50, 1.93	0.97	0.81	0.49, 1.33	0.41
Socioeconomic status (lowest)	1.22	0.48, 3.07	0.67	1.08	0.67, 1.76	0.75
Body mass index[d]	0.95	0.88, 1.02	0.15	1.00	0.97, 1.04	0.94
Current smoker	0.76	0.29, 1.94	0.56	1.51	0.92, 2.47	0.10
Current alcohol drinker	0.78	0.38, 1.62	0.51	0.96	0.64, 1.43	0.83
Low (vs. high) physical activity	1.75	0.97, 3.14	0.06	1.60	1.09, 2.34	0.02
Short Form-36 score[d]						
Physical	0.96	0.93, 0.99	0.006	0.97	0.95, 0.99	0.007
Mental	0.97	0.94, 1.00	0.05	1.01	0.98, 1.04	0.42
Depressive symptoms (yes)	0.63	0.23, 1.69	0.36	1.10	0.52, 2.30	0.81
Hypertension (yes)	0.89	0.47, 1.70	0.72	1.14	0.76, 1.69	0.57
Diabetes mellitus (yes)	0.92	0.12, 6.88	0.94	0.89	0.45, 1.73	0.72

Abbreviations: CI, confidence interval; OR, odds ratio.

[a] Odds ratios from multivariable logistic regression analyses (age × sex interaction terms were also included in the models).

[b] Odds ratios for age (continuous) are presented for men and women separately because of significant sex × age interactions.

[c] Weight (kg)/height $(m)^2$.

[d] Body mass index and physical and mental Short Form-36 scores were treated as continuous variables.

[e] Odds ratios for hypertension are presented for men and women separately because of a significant sex × hypertension interaction for short sleep duration.

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