SLEEP DISTURBANCE IN RELATION TO HEALTH-RELATED QUALITY OF LIFE IN ADULTS: THE FELS LONGITUDINAL STUDY

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Abstract: *Objective:* Sleep disturbances are prevalent problems in the general population. Symptoms of insomnia can impact various physical and mental conditions. Furthermore, sleep disturbances may worsen the quality of life independently of co-occurring medical conditions. In this study, we examined the relationships between self-reported sleep disturbance symptoms and health-related quality of life measures in the Fels Longitudinal Study. *Design:* Cross-sectional study. *Participants:* A total of 397 adults (175 men and 222 women) aged 40 years and older were included in the present study. *Measurements:* Three self-reported sleep disturbance measures (difficulty falling asleep, nocturnal awakenings and maintaining sleep, and daytime tiredness) were collected between 2003 and 2006. Health-related quality of life measures were assessed using the Medical Outcomes Survey Short Form (SF)-36. Socio-demographic status (marital status, employment status, and education) and current medical conditions were collected from participants during study visits. *Results:* Individuals who reported frequent sleep disturbances showed significantly worse quality of life on all SF-36 subscales examined. The odds ratio (OR) ranged from 1.71 to 18.32 based on symptoms of insomnia across seven SF-36 domains in analyses adjusted for significant covariates influencing quality of life. Participants with severe sleep disturbances (both sleep problems and daytime impairment) showed generally higher odds of reporting poor SF-36 scores (adjusted ORs; 5.88 – 17.09) compared to participants with no problems. *Conclusion:* Sleep disturbance is comprehensively and independently associated with poor health-related quality of life in middle-aged and older adults.

Key words: Sleep disturbance, daytime impairment, health-related quality of life, SF-36, middle-aged and older adults.

Introduction

Good quality sleep is intrinsically important in sustaining physical functioning and psychiatric well-being. Insomnia is a condition of poor quality of sleep or insufficient sleep. People with chronic insomnia can be identified by having any of the following symptoms for a prolonged period of time; 1) difficulty falling asleep, 2) awakening often during the night, 3) having difficulty getting back to sleep, or 4) awakening too early (1). The prevalence of insomnia varies from 16 to 21% according to various definitions used in research studies, population characteristics, and across various countries (2). According to a national survey by the National Sleep Foundation in the US, approximately 9% of adult respondents have symptoms of chronic insomnia or sleep disturbance (3). A more recent survey revealed that over 50% of older adults aged 55 – 84 years had sleep complaints such as trouble falling asleep or waking up repeatedly during the night (4). Other studies report that insomnia is significantly associated with diminished cognitive function including decreased psychomotor function and delayed response time (4-6). People suffering from insomnia are at increased risk for accidents, psychiatric disorders, increased health care utilization and reduced quality of life (4, 7, 8).

There are a number of epidemiologic studies examining the causes and prevalence of insomnia in the young and in older adults (3, 5, 7, 9-15). Few studies have examined the relationships between insomnia symptoms and physical and psychological consequences reflecting quality of life (16-19). Using the Medical Outcomes Study Short Form-36 questionnaire (SF-36), Zammit et al. reported that 261 participants with insomnia aged between 18 and 75 years showed significantly poorer quality of life scores on all eight of SF-36 sub-domains, compared to normal participants without reported sleep problems. Evidence also suggests that insomnia or sleep disturbance is closely related to the impairment of daytime functioning, resulting in sleepiness or tiredness (5, 20). Accordingly, more recent studies have included daytime sleepiness or fatigue due to sleep disturbances as a part of the symptoms of insomnia (11, 21). However, only a few existing studies have evaluated the impact of both insomnia symptoms and daytime consequences, such as sleepiness, on an individual's quality of life (8, 22).

The aims of this study were to estimate the prevalence of sleep disturbance and sleep related daytime impairment in a sample from the Fels Longitudinal Study and to determine

whether sleep problems and daytime consequence were associated with decreased health-related quality of life while controlling for the presence of co-morbidities and lifestyle factors related to quality of life. For our analysis, we used the standardized health-related quality of life scores from the SF-36 collected from men and women aged over 40 years.

Methods

Study population

The Fels Longitudinal Study began in 1929, and is the largest and longest running study of human growth, development, and body composition changes over the lifespan (23). Approximately 1,200 serial participants are currently enrolled in the study and almost all the participants are whites. In this study, we analyzed data from a subset of individuals who were seen at the study center between 2003 and 2006. A total of 397 adults who were 40 to 96 years of age, and had at least one set of sleep related data and concurrent quality of life measurements were included. Informed consent was obtained from participants and study protocols were approved by the Wright State University Institutional Review Board for Human Subjects Research.

Measurements

Self-reported sleep disturbance questions

Subjective sleep quality was assessed using a self-administrated questionnaire, modified version based on "Sleep Habits and Lifestyle Questionnaire" (24). Self-administrated questionnaires were mailed to participants before their study visits, and the study questionnaires were collected at individual's study visit. All forms are reviewed with the participants by research staff to assure completeness and comprehension of specific questions. The questions that pertained to sleep duration (e.g., average number of hours of sleep per night) and symptoms of insomnia were: 1) how often do you have difficulty falling asleep (sleep onset), 2) how often do you wake up during the night and have difficulty getting back to sleep (sleep maintenance). Daytime consequence related to sleep was assessed by asking participants the following question, 'how often do you feel not rested during the day no matter how many hours of sleep you had' (daytime tiredness). The measure of daytime tiredness served as a primary measure of the participants' general tendency to experience daytime impairment regardless of sleep duration. Sleep related questions were assessed using a five-point Likert scale with intervals defined as 'never or hardly ever', 'once or twice a month', 'once or twice a week', 'three or four times a week' or 'nearly every day'. Participants who experienced problems of sleep onset, sleep maintenance or daytime tiredness more than three times per week were coded as the positive 'sleep disturbance' group (25). To characterize severe sleep disturbance with daytime tiredness, participants who reported any symptoms of sleep onset and maintenance plus daytime tiredness were categorized into the 'severe sleep disturbance' group. Additionally, participants with only a sleep problem or with only daytime tiredness were categorized into two other additional groups. Participants with no 'positive' sleep disturbance were categorized as the reference group.

Health-related quality of life measures

Health-related quality of life was measured using the Medical Outcomes Survey SF-36 form (26). The SF-36 is a self-administered questionnaire with 36 questions which provides information on eight health domains; 1) ability to perform various physical activities ('physical functioning'), 2) problems with activities due to physical health ('physical health problems'), 3) intensity of pain and interference with activities ('bodily pain'), 4) self-evaluation of personal health ('general health'), 5) feeling energetic or tired ('vitality'), 6) limited ability to perform social activities due to physical health or emotional problems ('social functioning'), 7) problems with activities due to emotional health ('emotional health problems'), and 8) emotional health and well-being ('mental health'). Health-related quality of life has been frequently measured using the SF-36 in relation to other chronic diseases and has been validated (26-28). Participants' scores for the subscales range from 0 to 100 with the exception of physical functioning (range: 5 – 100), general health (range: 10 – 100) and mental health (range: 16 – 100). Higher scores for each domain represent a better perceived quality of life. All eight domain scores were calculated according to the algorithms recommended by Ware et al. and checked for scoring errors (26).

Demographic and lifestyle measures

Each participant provided demographic data including their marital status, education, and current employment status. Participants who reported being married or living with a partner were categorized into one group, while participants who were single, separated, divorced, or widowed were in another group. College graduates were those who reported completing a college or 4-year technical school degree or beyond. Participants were categorized as 'employed' based on their occupation. Those answering the occupation question as "unemployed", "housework or homemaker", "retired" or "stay at home" were collectively classified as non-employed.

Body weight and stature were measured according to standard anthropometric methods (29). Weight was recorded to the nearest 0.1 kg and stature was measured to the nearest 0.1 centimeters without shoes or heavy clothing. Body mass index (BMI) was calculated from body weight and stature (kg/m^2). Current smoking, alcohol consumption and use of prescribed hypnotics and/or sedatives were collected by questionnaire. Participants who reported to smoking cigarettes, cigars or pipes were coded as current-smokers. Alcohol consumers were those who consumed a 12 oz bottle of beer, 4 oz of wine, or 1 oz of

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hard liquor once or more weekly. Sport physical activity levels were measured using the Baecke Habitual Physical Activity questionnaire (30). A history of chronic medical conditions and use of prescribed hypnotics and/or sedatives was collected by both questionnaires and/or by direct measurements. Hypertension was defined as self-reported, physician diagnosed hypertension, systolic blood pressure greater than 140 mmHg and/or diastolic blood pressure greater than 90 mmHg, or the use of anti-hypertensive medication at the time of examination. Diabetes was defined as self-reported physician diagnosed type II diabetes, fasting glucose greater than 126 mg/dl, or the use of glucose-lowering medications. Coronary heart disease (CHD) was defined as self-reported physician diagnosed history of angina, atherosclerosis, myocardial infarction, and/or ischemia. Participants with rheumatoid arthritis or osteoarthritis were defined as having arthritis on the basis of self-reported, physician diagnosed history of conditions.

Statistical analysis

Descriptive statistics including means and standard deviations were calculated. T-tests were used to examine the differences in continuous variables such as age in association with sleep disturbance. Binary variables such as sex were compared between groups with or without sleep problems using chi-square tests or Fisher's exact test. The non-parametric methods of Wilcoxon-Mann-Whitney tests were applied to examine differences in health-related quality of life measures by the presence or absence of sleep problems.

Approximately 83.1% of participants reported the maximum possible score of 100 in emotional health problems subscale indicating there is not much variation in this domain among participants (i.e., ceiling effects). Thus, this subscale was not analyzed in further analyses examining the association between sleep problems and quality of life. We compared individuals who reported poor health related quality of life scores (defined as those in the lowest quartile for each domain) with individuals in the upper three quartiles using logistic regression. Multiple logistic regression analysis was performed to assess the impact of sleep disturbance on the odds of reporting poor quality of life scores. Covariates such as current medical conditions and lifestyle factors influencing quality of life measures were included and were retained based on significant relationships to outcome variables (e.g., poor physical functioning scores) based on stepwise regression modeling (p-value < 0.05). The estimated models were checked for model fit for each analysis. Statistical significance was set for p-value less than 0.05. All statistical analyses were conducted using SAS for Windows (version 9.1.3, SAS Inc, Cary, NC).

Results

Description of the sample

Table 1 shows the characteristics of all study participants. The mean age was 57.54 years (SD: 11.41 years, range: 40.0 –

96.6 years) and 55.9 % were female. Approximately 27.5% (n = 109) of the study participants were aged 65 years and older. More than 50% of the participants reported that they completed a college or 4-year technical school and beyond. A total of 303 (76.7%) participants were married or lived with a partner. Approximately 66% of the participants were categorized as currently employed. The mean BMI was 27.4 kg/m² (range: 15.9 – 47.7) and men had significantly higher BMI values compared to women. The mean scores for health-related quality of life measures in our population were comparable to the published national norms for the general U.S. population (26). Compared to younger participants (aged less than 65 years old), our older participants (i.e., aged over 65 years old) reported significantly lower scores (p-value < 0.05) in three of the health domains (i.e., physical functioning, physical health problems, and bodily pain). There were no significant differences between younger and older groups on reporting poor SF-36 scores in general health, vitality, and social functioning. The older group tended to report significantly better mental health compared to younger group. In general, our older participants seemed to report consistently higher scores in all domains when compared to reported national norms of the same age groups (26).

Table 1
Characteristics of study participants (n=397)

		Any sleep disturbances	
	Total	Yes (n=115)	No (n=282)
Age, years	57.54 (11.41)	57.00 (13.12)	57.77 (12.44)
Females (n, %)	222 (55.9)	73 (63.5)	149 (52.8)
College graduate (n, %)	227 (57.2)	53 (46.1)	174 (61.7)**
Married/living with a partner (n, %)ᵃ	303 (76.7)	82 (78.9)	221 (78.9)
Employed (n, %)	261 (65.7)	73 (63.5)	188 (66.7)
Body mass index, kg/m²	27.42 (5.41)	29.07 (6.01)	26.74 (5.00)***
Current smoking (n, %)	62 (15.6)	22 (19.1)	40 (14.2)
Current drinking (n, %)	199 (50.1)	44 (38.3)	155 (55.0)**
Sport activityᵇ	2.24 (0.68)	2.01 (0.61)	2.34 (0.68)***
Medical history (n, %)			
Hypertension	93 (23.5)	25 (21.7)	68 (24.3)
Coronary heart disease	15 (3.8)	5 (4.4)	10 (3.6)
Diabetes	34 (8.6)	15 (13.0)	19 (6.7)*
Arthritis	96 (24.2)	38 (33.0)	58 (20.6)**
Sleep durations (hours)	7.14 (1.04)	6.81 (1.19)	7.27 (0.95)***
Hypnotics/sedative medication (n, %)ᶜ	14 (3.5)	9 (7.8)	5 (1.8) **
*Quality of life scores*ᵈ			
Physical functioning	82.44 (21.85)	71.91 (26.71)	86.74 (17.88)***
Physical health problems	81.93 (33.37)	67.61 (39.46)	87.77 (28.63)***
Bodily pain	70.00 (21.95)	57.82 (25.48)	75.00 (18.17)***
General health	73.06 (17.94)	63.38 (20.62)	77.01 (15.06)***
Vitalityᶜ	60.69 (21.30)	43.26 (22.22)	67.83 (16.21)***
Social functioning	86.96 (22.12)	74.57 (28.29)	92.02 (16.63)***
Emotional health problemsᵉ	89.25 (26.52)	73.91 (38.18)	95.51 (16.26)***
Mental healthᶜ	79.22 (15.90)	69.81 (19.16)	83.07 (12.48)***

Data were presented as mean (standard deviation) otherwise indicated. Statistical significance between groups with and without sleep problems was denoted as *: p-value < 0.05, **: p-value <0.01, and ***: p-value < 0.001; a: n = 395; b: n = 394; c: n = 396; d: Statistical analyses were performed using non-parametric method (Wilcoxon-Mann-Whitney test); e: Approximately 83.1% of participants reported the maximum possible score of 100 and this domain was not further analyzed due to minimal variation between participants.

Study participants reported that they experienced sleep disturbances such as 'difficulty falling asleep' (n =54, 13.6%), 'frequent awakening and trouble getting back to sleep' (n=53, 13.5%), and 'daytime tiredness' during the daytime regardless of sleep duration (n=74, 18.6%). Of the 397 participants, approximately 29 % of the participants (n=115) had at least one or more problems related to sleep disturbance. Less than half of participants (n = 26) who experienced difficulty falling asleep had a problem of frequent awakening and trouble getting back to sleep. Interestingly, there was no significant difference in mean ages or by age groups (younger vs. older), and between sexes according to the presence of any sleep problems. There were significant differences in college education level, BMI, current drinking, and some medical history between participants with and without sleep disturbance indicating that participants with any sleep problems were heavier, less college-educated, more likely to have diabetes and arthritis, and had a lower tendency of drinking (all p-values < 0.05). Also, these participants with sleep disturbance reported to sleep less and to take more hypnotics/sedatives compared to those without sleep disturbance (p-value < 0.01). Participants with any sleep problems reported significantly decreased health-related quality of life scores in all eight domains, compared to those without any sleep problems (p-value < 0.001) (Table 1).

Odds of reporting poor quality of life scores for participants experiencing sleep problems

The odds of reporting poor quality of life scores were approximately two to four times higher among participants with some difficulty falling asleep for physical health problems, bodily pain, general health, vitality, social functioning and mental health scales after adjustment for significant covariates related to poor quality of life scores (Table 2). With the adjustment of significant covariates such as older age, less college education, higher BMI, and lower sport activity in the model, sleep onset problem was no longer significantly related to functional limitation doing vigorous or moderate daily activities (adjusted OR (95%CI); 1.71 (0.84 – 3.48)).

Table 2

Having 'difficulty falling asleep' in predicting poor SF-36 scores: univariate and multiple logistic regression

Poor SF-36 scores[a]	No (reference)	Unadjusted OR (95% CI) Yes	Adjusted OR (95%CI) Yes
Physical functioning	1.00	3.08 (1.71 – 5.55)	1.71 (0.84 – 3.48)[b]
Physical health problems	1.00	3.37 (1.87 – 6.07)	2.42 (1.28 – 4.56)[c]
Bodily pain	1.00	4.29 (2.37 – 7.77)	2.88 (1.47 – 5.63)[d]
General health	1.00	2.72 (1.50 – 4.92)	1.92 (1.01 – 3.68)[e]
Vitality	1.00	3.31 (1.84 – 5.96)	2.78 (1.46 – 5.27)[f]
Social functioning	1.00	3.72 (2.06 – 6.72)	3.04 (1.64 – 5.61)[g]
Mental health	1.00	3.84 (2.13 – 6.93)	3.90 (2.07 – 7.33)[h]

a. The quality of life scores were divided into two groups (the lowest quartile vs. the other three quartiles) as the lowest quartile score for outcome; b. Significant covariates in the model were age, college education, BMI, arthritis, and sport activity; c. Employment status, married/living with a partner, and arthritis; d. college education, living with a partner, and arthritis; e. BMI, arthritis, hypertension, sport activity, and current smoking; f. Age, BMI, married/living with a partner, and sport activity; g. Sex, BMI, and sport activity; h. Age, married/living with a partner, and diabetes

Frequent nocturnal awakenings and having trouble getting back to sleep was significantly related to all seven scales examined before and after the adjustment of various covariates for quality of life measures (Table 3). Participants who experienced a sleep maintenance problem were more than twice as likely to report poor physical function and general health scale scores. Also, these individuals were more than four times as likely to have poor mental health scale scores compared to participants with no problem or a lesser problem. Having a sleep maintenance problem was strongly related to feeling bodily pain and interference of pain in their normal activities (adjusted OR (95%CI); 5.17 (2.62 – 10.20)). Adjusting for various covariates such as suffering from arthritis increased the odds of an impaired feeling of bodily pain and worsened mental health among people with sleep maintenance problems.

Table 3

Having 'frequent awakenings & trouble to getting back to sleep' in predicting poor SF-36 scores: univariate and multiple logistic regression

Poor SF-36 scores[a]	No (reference)	Unadjusted OR (95% CI) Yes	Adjusted OR (95%CI) Yes
Physical functioning	1.00	2.45 (1.35 – 4.43)	2.21 (1.09 – 4.48)[b]
Physical health problems	1.00	2.93 (1.63 – 5.30)	2.65 (1.40 – 5.02)[c]
Bodily pain	1.00	4.95 (2.70 – 9.05)	5.17 (2.62 – 10.20)[d]
General health	1.00	2.34 (1.28 – 4.27)	2.02 (1.06 – 3.87)[e]
Vitality	1.00	3.47 (1.92 – 6.29)	2.99 (1.57 – 5.71)[f]
Social functioning	1.00	3.23 (1.78 – 5.85)	2.72 (1.46 – 5.07)[g]
Mental health	1.00	4.02 (2.22 – 7.30)	4.42 (2.31 – 8.43)[h]

a. The quality of life scores were divided into two groups (the lowest quartile vs. the other three quartiles) as the lowest quartile score for outcome; b. Significant covariates in the model were age, BMI, arthritis, and sport activity; c. Employment status, married/living with a partner, and arthritis; d. College education, married/living with a partner, and arthritis. e. BMI, arthritis, hypertension, sport activity, and current smoking; f. Age, BMI, married/living with a partner, arthritis, and sport activity; g. Sex, BMI, arthritis and sport activity; h. Age, employment status, married/living with a partner, and diabetes.

Participants reporting daytime tiredness were approximately three times as likely to have a poor bodily pain and social functioning scale score, and more than five times more likely to have poor physical functioning, physical health problems, general health and mental health scale scores (Table 4). Also, frequent daytime tiredness was significantly and negatively associated with the vitality score. People who experienced frequent daytime tiredness were 18 times more likely to have a poor vitality score (adjusted OR (95%CI); 18.32 (8.89 – 37.81)). Overall, participants with frequent 'daytime tiredness' were more likely to have greater odds of reporting poor quality of life (except 'bodily pain') compared to participants with other sleep problems.

To predict poor SF-36 scores among older participants (aged 65 years and over) with sleep problems, we performed a series of sub-group analyses (data not shown). Due to reduced sample sizes, adjusted ORs were significantly attenuated in predicting poor SF-36 scores among older participants having "difficulty falling asleep" or "frequent awakening & trouble getting back

to sleep". Interestingly, the significant relationships between daytime tiredness and poor SF-36 scores remained in the older group. Older participants having daytime tiredness reported significantly poorer SF-36 scores in all seven domains.

Table 4
Having 'daytime tiredness' in predicting poor SF-36 scores: univariate and multiple logistic regression

Poor SF-36 scores[a]	No (reference)	Unadjusted OR (95% CI) Yes	Adjusted OR (95%CI) Yes
Physical functioning	1.00	4.18 (2.46 – 7.08)	4.30 (2.17 – 8.52)[b]
Physical health problems	1.00	5.20 (3.05 – 8.87)	5.91 (3.27 – 10.68)[c]
Bodily pain	1.00	3.75 (2.22 – 6.34)	3.14 (1.75 -5.65)[d]
General health	1.00	6.21 (3.61 – 10.66)	4.95 (2.76 – 8.87)[e]
Vitality	1.00	21.80 (10.88 – 43.66)	18.32 (8.89 -37.81)[f]
Social functioning	1.00	4.34 (2.55 – 7.38)	3.46 (1.99 – 6.02)[g]
Mental health	1.00	6.63 (3.84 – 11.42)	6.97 (3.95 – 12.28)[h]

a. The quality of life scores were divided into two groups (the lowest quartile vs. the other three quartiles) as the lowest quartile score for outcome; b. Significant covariates in the model were age, BMI, arthritis, and sport activity; c. Age, sex, CHD, and arthritis; d. College education, married/living with a partner, and arthritis; e. BMI, arthritis, hypertension, sport activity, and current smoking; f. Age, married/living with a partner, and sport activity; g. Sex, BMI, and arthritis; h. Employment status, and married/living with a partner

Each sleep problem remained significant after adjusting for a number of lifestyle or current medical conditions related to poor SF-36 quality of life outcomes. While simultaneously adjusting for sleep problems in the multiple logistic regression models for poor quality of life measures, for example, older age, greater BMI and having arthritis were significantly associated with impaired physical function. Beyond having sleep problems, not being married or living with a partner was significantly related to greater bodily pain, impaired normal daily or work activities due to physical health, or worsened mental health. Similarly, being female, having greater BMI and having arthritis were related to higher odds of reporting impaired social function due to physical health and emotional problems. Participants who reported greater sport activity levels were less likely to report poor scores of physical functioning, general health, and vitality. Current smokers evaluated their personal health (i.e., 'general health') as poor in status compared to non-smokers. Also, participants who were employed reported to have less problems with their daily or work activities, but to have poor mental health.

Sleep problems with daytime impairment

Table 5 demonstrates the adverse relationships between severe sleep disturbance and quality of life measures. The odds of reporting poor quality of life ranged from 0.87 for the bodily pain scale to 3.04 for the mental health scale, while adjusting for significant covariates influencing quality of life. Compared to participants without any sleep problems or daytime tiredness, participants having severe sleep disturbance with both sleep problems and daytime tiredness were more likely to have lower scores on all seven of the scales examined. Adjusted ORs for

participants with severe sleep disturbance ranged from 5.46 (95%CI; 2.65 – 11.26) to 17.09 (95%CI: 6.89 – 42.21). Overall, the OR of reporting poor quality of life appears to be higher for participants with severe sleep disturbance than those for participants with only daytime tiredness except for the vitality scale (adjusted OR, 25.40) when these two groups were compared to those without any problems respectively.

Table 5
Having problems of sleep disturbance and daytime tiredness in predicting poor SF-36 scores

	Sleep problems with daytime tiredness			
	No problem (n=282)	Both sleep and daytime tiredness (n=40)	Sleep problems only (n=41)	Daytime tiredness only (n=34)
Physical functioning[a]	1.00	6.10 (2.54 – 14.67)	0.71 (0.29 – 1.77)	2.38 (0.90 – 6.28)
Physical health problems[b]	1.00	8.28 (3.82 – 17.96)	1.98 (0.93 – 4.20)	5.12 (2.31 – 11.33)
Bodily pain[c]	1.00	6.41 (2.89 -14.23)	2.41 (1.12 -5.20)	1.91 (0.83 – 4.40)
General health[d]	1.00	5.88 (2.77 – 12.47)	1.48 (0.65 - 3.35)	2.28 (1.19 – 4.38)
Vitality[e]	1.00	17.09 (6.89 – 42.21)	1.83 (0.86 – 3.87)	25.40 (8.25 – 78.79)
Social functioning[f]	1.00	5.46 (2.65 – 11.26)	2.49 (1.20 – 5.16)	2.85 (1.30 – 6.24)
Mental health[g]	1.00	12.83 (5.87 – 28.06)	3.01 (1.47 – 6.14)	5.57 (2.61 -11.59)

a. significant covariates included were age, BMI, arthritis, and sport activity; b. Age, and arthritis; c. College education, married/living with a partner, and arthritis; d. BMI, arthritis, hypertension, sport activity, and current smoking; e. Age, married/living with a partner, and sport activity; f. Sex, BMI, and arthritis; g. Employment status.

Discussion

This study reports that approximately 29% of our sample experienced at least one sleep disturbance symptom and about 10% of the participants suffer from severe sleep disturbance. Our results demonstrate that sleep problems have a negative impact on multidimensional health-related quality of life measures. The odds of worsened physical functioning (or any of the six other quality of life scales) were significantly higher among participants having frequent problems of sleep onset, sleep maintenance, or daytime tiredness (more than three times per week), compared with participants having no sleep problem or a sleep problem of lesser degree. Additionally, the adverse association of severe sleep disturbance with poor quality of life persisted even after adjusting for a number of demographic factors and current medical conditions that are known to adversely influence quality of life.

Sleep complaints such as difficulty falling asleep, frequent nocturnal waking, or waking too early are common in the adult populations (1, 3). In many epidemiologic studies, various definitions are used to characterize the prevalence of insomnia (see the review by Ohayon (2)). Since the prevalence of sleep disturbances is categorized based on the frequency of complaints per week, the prevalence rates in our study may not be directly comparable to studies that use a 'yes' or 'no' criteria for symptoms (9, 31). Furthermore, our results may not be directly comparable for populations of only older individuals

(7). Taking into consideration the different age distribution and definitions for insomnia, however, our prevalence rate for sleep disturbances related to insomnia symptoms are within the wide range of estimates observed in published studies (3, 11, 17). Insomnia symptoms are associated with decreased functioning and sleepiness during the day and with impaired quality of life (5). Epidemiologic studies have reported that people with insomnia or sleep disturbance had significantly reduced quality of life assessed using various generic and disease specific instruments (32). Among these, a few studies showed the negative impact of sleep symptoms on quality of life based on the SF-36 questionnaire (8, 17-19, 33, 34). In a recent study of middle-aged and older people, Schubert et al. demonstrated that the impact of sleep problems on quality of life was significant, and that participants reported worse quality of life scores as the number of sleep problems increased (17). Our study also shows that participants who complained of sleep difficulties reported significantly lower health-related quality of life scores compared to participants without sleep difficulties for all SF-36 scales (p-value < 0.001). Even though the SF-36 does not specifically contain sleep disorder related questions, lower scores in eight scales of the SF-36 are correlated well with poor sleep quality or symptoms of insomnia (33).

Since the distributions of the eight SF-36 scales are skewed and not normal, we chose to compare the lowest quartile score (25 percentile cut-off) with the other three quartile groups and to adjust for potential demographic, lifestyle or coexisting medical risk factors in this paper. Multiple logistic models produced similar results indicating lower scores in participants with sleep disturbance, daytime tiredness, or insomnia to those results reported by Zammit et al. (19). While Zammit et al.'s results were based on only age-adjusted models, our study demonstrates consistent associations between poorer quality of life scores and sleep problems even after adjusting for significant factors related to quality of life, such as pre-existing medical condition or social relationship.

The adjusted ORs of having poor quality of life among our participants with sleep onset and maintenance problems range from 1.91 to 5.23 and were higher in magnitude compared with a study by Baldwin et al (33). Interestingly, we found that the pattern of relationships between poor quality of life in various domains (i.e., bodily pain, mental health, vitality or social functioning) and sleep problems differed among participants complaining of frequent nighttime awakening and trouble getting back to sleep and those complaining of difficulty falling asleep. For instance, the strongest relationship between poor quality of life and sleep onset was found in the mental health domain (adjusted OR (95%CI); 3.90 (2.07 – 7.33)) followed by the second strongest relationship with social functioning. The association between the bodily pain scale and sleep disturbance appears to be different between the respondents of having difficulty falling asleep and those of having frequent nocturnal awakenings. The bodily pain scale was more adversely associated with a sleep maintenance problem (adjusted OR

(95%CI), 5.17 (2.62 – 10.20)). Participants with a sleep maintenance problem are prone to report more severe bodily pain due to the sleep problem even after adjusting for significant factors (married, education levels or arthritis) related to bodily pain scale. This result is similar but slightly stronger than in a recent study by Foley et al. (4). According to 2003 National Sleep Foundation Survey of 1506 people aged over 55 years, authors reported that people with the insomnia symptom of frequent nocturnal awakenings had approximately 2.7 times higher odds of reporting a poor bodily pain score compared to people without any symptoms of insomnia, whilst people with difficulty falling asleep had less than two times higher odds of reporting a poor bodily pain score (4). It is possible that participants with frequent and prolonged awakenings are more likely to suffer from other sleep disorders including sleep apnea or restless leg syndrome, chronic pain and other medical conditions so that the individuals are less able to cope with pain caused by various physical or psychological conditions. This finding may corroborate the view that there are some differences in biological mechanisms or related pathways between sleep-onset insomnia and sleep maintenance insomnia. In turn, these two types of insomnia may differentially influence the individuals' perceived pain intensity and limitation in activities.

Specifically, we found that participants with both sleep problems and daytime impairment had poorer quality of life scores. The adjusted odds of reporting poor scores for six SF-36 domains (physical functioning, physical health problems, bodily pain, general health, social functioning, and mental health) examined was 5.5 times or greater in participants with both sleep and daytime problems. Among the questions of the SF-36, the vitality domain reflects personal daytime functioning such as energy, fatigue or exhaustion. It is, therefore, not surprising to see that the highest odds of a poor vitality score are among people with complaints of daytime sleepiness or tiredness. We also found the second highest odds of having poor vitality in participants with both nocturnal sleep and daytime problems compared to those with no problems. These results were consistent with the observations reported in a few other studies (8, 35). Based on a study of over 3000 managed care organization enrollees, Hatoum et al. suggested that daytime consequences resulting from insomnia had more adverse influences on physical and mental health during the day than nighttime sleep problems (8). Thus, it also makes sense that daytime impairment with or without sleep problems would be associated strongly with the mental health domain which reflects psychological distress and the perception of happiness.

Although our study participants seem to be healthier (or report better overall mean scores in certain domains of health-related quality of life compared to the published national norms) (26), we show that the reported sleep problems have a clear negative impact on health-related quality of life measures. Problems of sleep onset, maintenance and insomnia with daytime tiredness show a different pattern of relationship with

quality of life scales. As noted in the literature, sleep disturbances or symptoms of insomnia can be influenced by many different modifiable or non-modifiable risk factors or by co-morbidities which have a large impact on health-related overall life satisfaction (36). However, these adverse relationships between sleep problems and quality of life persisted even after we adjusted for various lifestyle factors related to quality of life.

It is important to note that our study has some limitations. This report is based on cross-sectional data so it is not feasible to establish a causal association between sleep disturbances and health-related quality of life. We should not exclude the possibility of reverse causation between sleep disturbance and poor quality of life. For example, it is possible that increased bodily pain related to chronic conditions such as arthritis may cause sleep disturbance and, in turn, is related to poor quality of life. We have attempted, however, to adjust for these factors in our analysis where possible. Potential biases due to the inclusion of some participants with certain psychiatric disorders (e.g., depression) warrant careful consideration in interpreting the adverse relationships between sleep and quality of life since these psychiatric symptoms were not directly assessed in the present study. Studies suggest that insomnia symptoms may be a premonitory symptom for depression or anxiety disorders (31, 37). Conversely, psychiatric disorders or symptoms may result in poor sleep or insomnia which is consequently related to poor quality of life (5, 38). We examined the use of antidepressant medication reported in our study participants as a proxy for psychiatric disorders, and found approximately 12.6% of participants reported to use anti-depressant medications. When we adjusted the use of anti-depressant medications in multivariable logistic models, however, we found that the adjusted ORs of sleep disturbance variables were not significantly changed in predicting poor quality of life (data not shown). Therefore, we could suggest that these results are not likely to be strongly biased due to inclusion or participants with mental health diagnosis. Our results may not be directly comparable to other studies applying various diagnostic criteria for chronic insomnia or studies separating sleep disorders such as obstructive sleep apnea or sleep movement disorders. Our questions include asking the frequency of insomnia experience per month and week, without using a specific reference period of time (e.g., past month). This results in the inclusion of participants with acute insomnia as well as chronic insomnia. There are a number of different diagnostic criteria used for diagnosis of primary and secondary insomnia (i.e., insomnia co-occurring with medical conditions) including the Diagnostic and Statistical Manual of Mental Disorders-IV, or International Classification of Sleep Disorders (21, 39). Our study was primarily based on non-Hispanic ambulatory whites, thus these results may not be applicable to other ethnic backgrounds, younger or institutionalized (e.g., nursing home bound) people. Our long-term serial study of health also leads to a potential cohort bias in that our population has slightly better health-related quality of life in older (over 60 years) participants when we compared to those from the general US population norms (26).

In conclusion, our study demonstrates that sleep disturbances are moderately prevalent in healthy adults aged 40 years and older, and these sleep problems are adversely associated with quality of life. Our findings lend support for future studies that will measure sleep quality using psychometrically validated instruments and will examine sleep disturbance and the quality of the physical and mental health of normal adults.

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