# Excessive Daytime Sleepiness in Young Adults: A 20-Year Prospective Community Study

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***Objective:*** Excessive daytime sleepiness (EDS) is a symptom with high clinical and public health importance because of its association with increased risk for accidents, decreased productivity, and impaired quality of life. Little information is available regarding the longitudinal course or clinical correlates of EDS. The aim of this study was to explore associations between self-reported EDS, sleep disorder symptoms, major depression, and anxiety in a longitudinal community study of young adults.

***Method:*** A prospective single-age community study of young adults (Zurich Cohort Study) was conducted from 1978 through 1999. Information was derived from 6 interviews administered when participants (N = 591) were ages 20, 22, 27, 29, 34, and 40 years. Trained health professionals administered a semistructured interview for health habits and psychiatric and medical conditions. The presence of either or both of 2 symptoms—accidentally falling asleep or excessive need for sleep during the day—was used to establish the presence of EDS.

***Results:*** EDS was a common complaint among the study participants, with increasing prevalence with age. Cross-sectionally, EDS was associated with insomnia symptoms, nocturnal hypersomnia, anxiety disorders, somatization, and reduced quality of life. Longitudinally, impaired sleep quality, waking up too early, and anxiety were associated with later EDS. Conversely, EDS was not significantly associated with later anxiety or depressive disorders.

***Conclusions:*** Insomnia symptoms and anxiety are associated with the subsequent occurrence of EDS. Although these findings do not demonstrate causality, insomnia and anxiety disorders are prevalent and treatable conditions, and our results may have important clinical implications for the prevention and treatment of EDS. Whether the results of this study are limited to populations with elevated levels of psychopathology remains to be tested.

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Excessive daytime sleepiness (EDS) is a symptom with high clinical and public health importance. Excessive sleepiness has been implicated in approximately 16% of motor vehicle accidents,[1] and habitually sleepy drivers have a more then 10-fold higher frequency of auto crashes than nonsleepy controls.[2] In addition, it has been estimated that half of work-related accidents and a quarter of home-based accidents are related to sleepiness.[3] In non–shift workers, for instance, EDS is associated with a more than 2-fold increased risk of sustaining an occupational injury.[4] Prevalence rates for daytime sleepiness interfering with daily activities are approximately 20% to 43%,[5] underlining its considerable impact on public health. Previous cross-sectional epidemiologic studies showed that EDS is associated with short sleep duration, insomnia symptoms, sleep-disordered breathing, major depression, and somatic distress.[6–8] Data on associations between sex and EDS[8–10] and on the effect of age on EDS[7,8] have been less consistent.

Objective measures of sleep efficiency and total sleep time, and other aspects of nocturnal polysomnographic recordings, have not been consistently related to measures of daytime sleepiness. In fact, total sleep time has been correlated with increased tendency for drowsiness,[11] and better nighttime sleep has been correlated with increased sleep tendency during the day among both insomniacs and noninsomniacs.[12] Psychopathology, at either a clinical or subclinical level, may also help to account for both nighttime sleep problems and EDS.[13]

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Cross-sectional epidemiologic studies have been limited in their ability to increase our understanding of these mechanisms. Clinical studies, on the other hand, may be vulnerable to biases related to the effects of treatment or help-seeking behavior. Therefore, longitudinal studies in community samples may help to clarify the relationship between EDS, nighttime sleep, and psychopathology.

There are few published data on the longitudinal course of EDS.[10,14] The purpose of the current study was to explore associations between EDS, sleep symptoms, major depression, and anxiety in a longitudinal community study of young adults followed up from ages 20 to 40.

## METHOD

### Sample

The Zurich Cohort Study was designed to investigate classification, incidence, prevalence, course, and causal and course-modifying factors of psychiatric and psychosomatic syndromes.[15] It comprises a cohort of 4547 subjects (2201 males, 2346 females) representative of the canton of Zurich in Switzerland, who were assessed in 1978 with a psychological symptom questionnaire, the Symptom Checklist 90-R (SCL-90-R),[16] and a questionnaire for sociodemographic data. The study is a single-age cohort based on a stratified sample with an overrepresentation of risk cases for psychiatric disorders. In order to increase the probability of somatic and psychological syndromes, a subsample of 591 subjects (292 males, 299 females) was selected for interview, with two thirds consisting of high scorers (defined by the 85th percentile or more of the SCL-90-R) and a random sample of those with scores below the 85th percentile. After a complete description of the study to the subjects, informed consent was obtained from subjects according to the requirements of the Swiss National Science Foundation. The screening took place in 1978 when subjects were 19 years of age, the first and second interviews in 1979 and 1981, the third and fourth interviews in 1986 and 1988, the fifth interview in 1993, and the sixth in 1999.

Across 20 years, 62.1% of the original sample continued to participate in the study. The following proportions participated in specific numbers of interviews: 47% in all 6 interviews, 63% in 5 interviews, 74% in 4 interviews, 82% in 3 interviews, and 91.4% in at least 2 interviews. Those who had dropped out did not differ significantly from participants in 1999 regarding the risk group at study entry and most demographic characteristics.[17] In addition, those who had dropped out between 1986 and 1999 did not differ significantly from participants who participated in all 4 interviews regarding baseline predictors including any anxiety disorder, major depression, insomnia (diagnosis), and fatigue/sleepiness at ages 20 and 22 (analyzed by $\chi^2$ tests). Likewise, EDS at ages 27, 29, or 34 was not associated with later dropout (analyzed by $\chi^2$ tests).

### Diagnostic Interview

The diagnostic instrument used in the Zurich study was the Structured Psychopathological Interview and Rating of the Social Consequences for Epidemiology (SPIKE),[15] a semistructured interview for psychiatric and medical conditions and health habits that was developed for epidemiologic studies. Health professionals with extensive clinical training administered the SPIKE in the participants' homes.[18] This interview schedule assesses a number of somatic syndromes, including sleep behaviors and sleep disorder symptoms, weight problems, headache, and gastrointestinal, cardiovascular, respiratory, perimenstrual, and sexual syndromes. In addition, it assesses psychological syndromes including depression, hypomania, anxiety, phobia, obsessive-compulsive disorder, posttraumatic stress disorder, substance abuse, and suicidality. Personal and family history of the syndromes was assessed for all subjects. Diagnoses of psychiatric disorders and insomnia were made by algorithms on the basis of DSM-III-R[19] and DSM-IV[20] criteria. The diagnosis of insomnia included symptoms of difficulty initiating or maintaining sleep and a minimum duration of 1 month. *Any anxiety disorder* was defined as having simple phobia, social phobia, agoraphobia, panic disorder, generalized anxiety disorder, and/or obsessive-compulsive disorder. Impairment in quality of life in various domains was assessed with a disease-independent quality-of-life scale.[21]

The validity of the SPIKE has been assessed by comparing physician ratings and medical records to an administration of the SPIKE by another clinician among 140 patients drawn from medical and psychosocial services in the canton of Zurich[22–24] and from a local hospital.[25] The SPIKE diagnostic rating of depression was found to have high sensitivity and adequate specificity (0.95 and 0.59, respectively, for major depression and 0.83 and 0.63, respectively, for minor depression). An important limitation of the SPIKE, particularly with regard to somatization symptoms, is that it does not include a physical examination or other medical tests.

### Assessment of Excessive Daytime Sleepiness

Psychometric evaluation studies have shown that EDS is a valid construct. It has adequate divergent validity from nocturnal sleep onset characteristics, and assessment by self-report predicts scores obtained by the Multiple Sleep Latency Test,[26] which represents the gold standard of EDS assessment. For the current study, EDS was assessed by 2 questions on the semistructured interview administered in 1986, 1988, 1993, and 1999. Subjects were asked if they had had sleep/wake problems in the last 12 months. Positive endorsement of the probe question was followed by queries about specific symptoms including (1) accidentally falling asleep, for example while watching TV or listening to the radio or to a

talk, and (2) excessive need for sleep during the day. Both items were answered by yes or no. The presence of either or both symptoms was used to establish the presence of EDS in the current study (dichotomous outcome variable). The interviews administered in 1979 and 1981 included an item regarding excessive fatigue and/or excessive sleepiness during the day. Because the interest of the current study was EDS as being distinct from fatigue, we did not consider the response to that item to be an estimate of EDS; however, we used that item as a baseline predictor of EDS.

### Assessment of Nocturnal Sleep Symptoms

In the interviews administered in 1986, 1988, 1993, and 1999, all subjects were asked about their general sleep quality ("how well do you normally sleep?"). There were 3 response options: good/no impairment, moderately impaired sleep quality, and severely impaired sleep quality. Subjects were then asked if they had had specific sleep problems in the last 12 months. Positive endorsement of the probe question was followed by queries about specific symptoms including trouble falling asleep, awakenings during sleep period, nocturnal anxiety states, waking up too early, trouble getting up in the morning, and daytime worry about nocturnal sleep. All items were answered by yes or no. These symptom queries were followed by questions about the course of the sleep problems (number of episodes, duration of episodes) and the treatments that subjects received for their sleep problems.

### Assessment of Sleep Duration

Previous studies comparing self-reported sleep duration with quantitative rest-activity measurements obtained by actigraphy found good correlation between these methods[27,28]: particularly good correlations were found when comparing the measurement of sleep onset time ($r = 0.77$) and sleep offset time ($r = 0.88$), while the measurement of sleep latency was poorly correlated ($r = 0.12$). For the Zurich study, 3 questions concerning sleep duration were assessed by interview: (1) time (hours and minutes) subjects went to bed, (2) time (hours and minutes) subjects arose, and (3) time (minutes) subjects needed to fall asleep. Sleep duration was calculated as duration spent in bed (1, 2) minus time needed to fall asleep (3). In addition, there were 2 questions regarding the subjective perception of nocturnal sleep duration: (1) desired sleep duration ("how long would you like to sleep each night?" with response given in hours and minutes), and (2) nocturnal hypersomnia ("do you sometimes get too much sleep at night?" with yes/no response).

### Assessment of Personality

Personality traits were assessed by the Freiburg Personality Inventory (FPI; half form B[29]), a self-report inventory, which is the most widely used personality index in German-speaking countries. The FPI was administered to subjects at the third and fourth interview, and scores were highly stable across interviews. Nine primary factors can be derived from the instrument (life satisfaction, social orientation, performance orientation, inhibition, excitability, strain, somatic distress, health worries, and social desirability). Three alternative secondary factors (aggression, extraversion, and autonomic lability) were derived through factor analysis of a large population-based study in Switzerland.[30] These z-transformed factors (mean = 0, standard deviation = 1) were used in the current study, because they provided a better fit to the data and were more representative of the current sample of young Swiss adults than the factors developed by the original authors of the instrument. The factor autonomic lability is similar to the personality dimension neuroticism.

### Statistical Analyses

Prevalence rates of EDS in the stratified sample with an overrepresentation of risk cases for psychiatric disorder were weighted back to reflect the original sample (N = 4547) being representative of the general population.

On the basis of previous studies,[6–14,31–34] we selected the following measures as correlates and potential predictors of EDS: age, sex, major depression, any anxiety disorder, personality traits, alcohol abuse/dependence, smoking, educational level, socioeconomic status, actual sleep duration in hours, sleep latency in hours, short sleep duration (< 6 hours), circadian preference (0 = bedtime before/at midnight, 1 = bedtime after midnight), desired sleep duration in hours, use of hypnotics, use of antidepressants and anxiolytics, being overweight (body mass index > 25), and sleep symptoms, including trouble falling asleep, impaired sleep quality, awakenings during sleep period, nocturnal anxiety states, waking up too early, nocturnal hypersomnia, trouble getting up in the morning, and daytime worry about nocturnal sleep. Potential consequences of EDS such as impaired quality of life and other concomitants of EDS such as somatic distress were included in separate analyses because they were not seen as potentially direct predictors.

The first data analytic stage included the exploration of bivariate cross-sectional associations between EDS and its potential correlates. Data for the cross-sectional analyses were assembled in panel format (i.e., multiple records per patient, with 1 record for each interview for which data were available). We used generalized estimating equations (GEE)[35] on repeated measures with subject as cluster, and a first-order autoregressive within-cluster correlation structure including all available EDS measures in 1986, 1988, 1993, and 1999 of all study subjects as the dependent variable and each potential correlate as concurrent independent variable. Age, sex, and stratified



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Table 1. Weighted 1-Year and Cumulative Prevalence Rates[a] of Excessive Daytime Sleepiness in Young Adults in a 20-Year Prospective Study

| | | Women | | Men | | Total | |
|---|---|---|---|---|---|---|---|
| Year of Interview | Age, y | N | Prevalence, % | N | Prevalence, % | N | Prevalence, % |
| 1986 | 27 | 232 | 12.7 | 225 | 6.2 | 457 | 9.4 |
| 1988 | 29 | 224 | 12.5 | 200 | 12.4 | 424 | 12.4 |
| 1993 | 34 | 215 | 16.2 | 192 | 14.5 | 407 | 15.4 |
| 1999 | 40 | 205 | 29.8 | 162 | 21.8 | 367 | 26.1 |
| Any interview | | 252 | 42.2 | 247 | 32.8 | 499 | 37.5 |

[a]Prevalence rates were weighted back to reflect the original sample (N = 4547).

sampling (0 = SCL-90-R low scorer, 1 = SCL-90-R high scorer) were included as covariates. The form of the GEE model is similar to that used in ordinary logistic regression, but the methods used to estimate the parameters are modified to account for the correlation between repeated measures on the same subject.

The second analytic stage included the multivariate cross-sectional analysis of EDS and its potential correlates. In this GEE model, we included EDS as dependent variable and all significant predictors of the bivariate analyses as independent (concurrent) correlates. We did not include personality variables and the variable coding the difference between the desired and the actual sleep duration because they were not available across all interviews between 1986 and 1999. A secondary analysis including these variables for the available time points revealed that they were not significant predictors of EDS in the multivariate model.

The third analytic stage was aimed at exploring longitudinal associations between EDS and its baseline predictors. Based on previous studies,[6–14,31–34] we considered female sex, stratified sampling, major depression, any anxiety disorder, insomnia (diagnosis), and fatigue/sleepiness at ages 20 and 22 years as baseline predictors of EDS. We used logistic regression to estimate associations between baseline variables and EDS when subjects were ages 27, 29, 34, and 40 years (cumulative diagnosis). In the first logistic model of EDS, baseline variables were included separately. In the second logistic model, all baseline variables were simultaneously included in a multivariate logistic model of EDS.

In the fourth analytic stage, aimed at exploring predictive associations between clinical variables and EDS, we estimated multivariate associations between cumulative exposure to clinical predictors and later EDS. For this purpose, we calculated robust estimates of repeated measures (i.e., data were assembled in panel format) by GEE[35] with subject as cluster, and a first-order autoregressive within-cluster correlation structure. This model included the fixed predictor sex and the time-varying exposure variables major depression, any anxiety disorder, being overweight, and sleep symptoms as being significant in the multivariate cross-sectional analysis, and EDS as subsequent (lagged) outcome variable at 3 time points. EDS in 1986, stratified sampling, and age were included as covariates. Associations between cumulative exposure variables (1986, 1986/1988, and 1986/1988/1993) and EDS in 1988, 1993, and 1999 were estimated in the same GEE model adjusted for the correlation between repeated measures on the same subject. We did not include data from interviews administered in 1979 and 1981 in the longitudinal GEE models because certain sleep characteristics, including sleep quality, were not assessed in these interviews.

To examine the converse question, i.e., EDS as predictor of psychopathology, we used the same models with EDS as cumulative exposure variable and any anxiety disorder or major depression as response variables (in 1988, 1993, and 1999). These models were adjusted for the time-invariant covariates sex, stratified sampling, and baseline psychopathology (any anxiety disorder or major depression in 1986), and for the time-varying covariates age, trouble falling asleep, impaired sleep quality, awakenings during sleep period, waking up too early, and trouble getting up in the morning.

SAS for Windows release 8.02 (SAS Institute Inc., Cary, N.C.) was used for all statistical analyses. We used PROC GENMOD for the GEE models and PROC LOGISTIC for simple logistic regression. The macro COLLIN from SAS-L by Mathew Zack was used to calculate collinearity diagnostics from the variance covariance matrix of the GEE models.[36]

## RESULTS

Table 1 presents prevalence rates of EDS in men and women at ages 27, 29, 34, and 40 years. In both men and women, prevalence rates of EDS increased with age, with the largest increase being seen between the ages of 34 and 40. Women had higher prevalence rates than men at all ages.

### Bivariate Cross-Sectional Associations (Table 2)

Nocturnal sleep symptoms including trouble falling asleep, awakenings during the sleep period, nocturnal anxiety, impaired sleep quality, and nocturnal hypersomnia were strongly associated with concurrent EDS. Nocturnal hypersomnia was not associated with insomnia.

**Table 2. Bivariate Cross-Sectional Associations Between Clinical Variables and Excessive Daytime Sleepiness**

| Variable | Frequency, %[a] | Odds Ratio (95% CI)[b] |
|---|---|---|
| Age (unit = 10 years) | | 1.8 (1.4 to 2.2)*** |
| Female sex | 50.6 | 1.4 (1.1 to 1.9)* |
| Major depression | 29.9 | 1.9 (1.4 to 2.7)*** |
| Any anxiety disorder | 35.1 | 2.5 (1.8 to 3.3)*** |
| Alcohol dependence/abuse | 23.5 | 1.8 (1.3 to 2.6)** |
| Smoking | 46.1 | 1.2 (0.9 to 1.5) |
| Low educational level (≤ 9 years vs > 9 years of education) | 35.5 | 1.4 (1.0 to 1.9)* |
| Low socioeconomic status (worker vs employee, college graduate) | 52.6 | 1.0 (0.7 to 1.4) |
| Impaired sleep quality[c] | 37.9[c] | 2.9 (2.3 to 3.6)*** |
| Insomnia diagnosis (≥ 1 mo) | 35.7 | 2.8 (2.1 to 3.8)*** |
| Insomnia symptoms | | |
| Trouble falling asleep | 62.5 | 6.8 (5.1 to 9.0)*** |
| Awakenings during sleep period | 57.5 | 7.7 (5.7 to 10.2)*** |
| Nocturnal anxiety states | 32.5 | 4.1 (2.9 to 5.7)*** |
| Waking up too early | 41.7 | 5.0 (3.8 to 6.7)*** |
| Nocturnal hypersomnia | 44.1 | 3.0 (2.2 to 3.9)*** |
| Trouble getting up in the morning | 60.7 | 9.7 (7.2 to 13.1)*** |
| Daytime worry about nocturnal sleep | 19.2 | 3.8 (2.5 to 5.8)*** |
| Sleep duration, h | | 0.9 (0.8 to 1.1) |
| Short sleep duration (< 6 h) | 19.2 | 1.1 (0.7 to 1.8) |
| Difference desired/actual sleep duration, h | | 1.2 (1.0 to 1.4)* |
| Sleep latency, h | | 1.5 (1.0 to 2.2) |
| Bedtime after midnight | 44.8 | 1.0 (0.7 to 1.4) |
| Use of hypnotics | 20.6 | 2.7 (1.9 to 4.0)*** |
| Use of antidepressants or anxiolytics | 17.4 | 1.7 (1.1 to 2.6)* |
| Being overweight (BMI > 25) | 27.8 | 1.4 (1.0 to 1.9)* |
| Personality[d] | | |
| Aggression | | 1.2 (1.1 to 1.4)** |
| Extraversion | | 0.9 (0.8 to 1.0) |
| Autonomic lability | | 1.6 (1.3 to 1.8)*** |

[a]Unweighted cumulative 1-year frequency rates.
[b]Concurrent associations (within the same year) in 1986, 1988, 1993, and 1999, estimated by generalized estimating equations, adjusted for sex and stratified sampling.
[c]Rate includes subjects with moderately and severely impaired sleep quality (0 = not impaired, 1 = moderately impaired, 2 = severely impaired).
[d]Standardized scores: mean = 0, standard deviation = 1.
*p < .05.
**p < .01.
***p < .001.
Abbreviation: BMI = body mass index.

**Table 3. Multivariate Cross-Sectional Associations Between Clinical Variables and Excessive Daytime Sleepiness**

| Variable | Odds Ratio (95% CI)[a] |
|---|---|
| Age (unit = 10 years) | 1.9 (1.4 to 2.6)*** |
| Female sex | 1.0 (0.7 to 1.4) |
| Major depression | 1.0 (0.6 to 1.6) |
| Any anxiety disorder | 1.6 (1.1 to 2.4)* |
| Alcohol dependence/abuse | 1.5 (0.9 to 2.4) |
| Low educational level[b] | 1.2 (0.9 to 1.8) |
| Impaired sleep quality[c] | 1.4 (1.0 to 2.0)* |
| Insomnia symptoms | |
| Trouble falling asleep | 2.2 (1.5 to 3.3)*** |
| Awakenings during sleep period | 2.5 (1.6 to 3.7)*** |
| Nocturnal anxiety states | 0.9 (0.6 to 1.5) |
| Waking up too early | 1.8 (1.2 to 2.6)** |
| Nocturnal hypersomnia | 1.8 (1.3 to 2.6)*** |
| Trouble getting up in the morning | 3.4 (2.3 to 5.0)*** |
| Daytime worry about nocturnal sleep | 1.0 (0.6 to 1.8) |
| Use of hypnotics | 0.9 (0.6 to 1.5) |
| Use of antidepressants or anxiolytics | 1.1 (0.6 to 2.0) |
| Being overweight (BMI > 25) | 1.5 (1.0 to 2.2)* |

[a]Concurrent associations (within the same year) in 1986, 1988, 1993, and 1999, estimated on repeated measures by generalized estimating equations, adjusted for sex and stratified sampling.
[b]≤ 9 years vs. > 9 years of education.
[c]Rate includes subjects with moderately and severely impaired sleep quality (0 = not impaired, 1 = moderately impaired, 2 = severely impaired).
*p < .05.
**p < .01.
***p < .001.
Abbreviation: BMI = body mass index.

Nocturnal sleep duration, sleep latency, short sleep duration (< 6 hours), and circadian preference (bedtime after midnight) were not associated with EDS. The absolute difference between the desired sleep duration and the actual sleep duration was positively associated with EDS, regardless of whether subjects wished to sleep more or less than they actually did.

There were strong cross-sectional associations between EDS and major depression, anxiety disorders, alcohol dependence/abuse, and use of hypnotics. Among the personality variables, autonomic lability and aggression were strongly associated with EDS. Bivariate cross-sectional associations between antidepressant/anxiolytic use, being overweight, and low educational level also reached statistical significance. Smoking and socioeconomic status were not associated with EDS.

### Multivariate Cross-Sectional Associations (Table 3)

In the multivariate analysis, trouble getting up in the morning, awakening during the sleep period, trouble falling asleep, and nocturnal hypersomnia were the strongest concurrent correlates of EDS. Impaired sleep quality and waking too early also remained significant correlates of EDS. Among the psychiatric disorders, anxiety disorders were the only significant correlates of EDS. Finally, age and being overweight remained significant positive predictors of EDS in the multivariate model.

### Longitudinal Associations (Tables 4 and 5)

Table 4 shows associations between baseline demographic variables, psychiatric disorders, and stratified sampling derived from interviews administered in 1979 and 1981 and cumulative EDS derived from interviews administered in 1986, 1988, 1993, and 1999. Subjects in the high-risk sample had an increased risk for EDS relative to subjects in the low-risk sample (high vs. low SCL-90-R scores in 1978). Major depression and insomnia diagnosis at ages 20 and 22 years were not associated with later EDS. However, any anxiety disorder and fatigue/sleepiness at ages 27 and 40

**Table 4. Baseline Predictors of Excessive Daytime Sleepiness Between Ages 27 and 40 Years (cumulative diagnosis)**

| Association | Bivariate, Odds Ratio (95% CI) | Multivariate, Odds Ratio (95% CI) |
|---|---|---|
| Female sex | 1.6 (1.1 to 2.3)* | 1.4 (1.0 to 2.1) |
| SCL-90-R high scorer vs low scorer sample | 1.6 (1.1 to 2.4)* | 1.4 (1.0 to 2.1) |
| Major depression at ages 20 or 22 | 1.4 (0.8 to 2.3) | 0.9 (0.5 to 1.6) |
| Any anxiety disorder at ages 20 or 22 | 2.3 (1.4 to 3.8)*** | 2.0 (1.2 to 3.3)* |
| Insomnia diagnosis at ages 20 or 22 | 1.4 (0.9 to 2.2) | 1.3 (0.8 to 2.1) |
| Fatigue/sleepiness at ages 20 or 22 | 1.8 (1.2 to 2.6)** | 1.5 (1.0 to 2.2) |

*p < .05.
**p < .01.
***p < .001.
Abbreviation: SCL-90-R = Symptom Checklist 90-Revised.

**Table 5. Multivariate Longitudinal Associations Between Clinical Variables (cumulative exposure) and Later Excessive Daytime Sleepiness (EDS)**

| Variable | Odds Ratio (95% CI)[a] |
|---|---|
| Age (unit = 10 years) | 2.0 (1.2 to 3.3)** |
| Female sex | 1.1 (0.8 to 1.6) |
| Major depression | 1.0 (0.7 to 1.5) |
| Any anxiety disorder | 1.5 (1.0 to 2.1)* |
| Impaired sleep quality[b] | 1.4 (1.0 to 1.8)* |
| Trouble falling asleep | 0.9 (0.6 to 1.3) |
| Awakenings during sleep period | 1.1 (0.7 to 1.8) |
| Waking up too early | 1.6 (1.1 to 2.4)* |
| Nocturnal hypersomnia | 1.1 (0.8 to 1.5) |
| Trouble getting up in the morning | 1.2 (0.8 to 1.9) |
| Being overweight (BMI > 25) | 1.3 (0.8 to 2.0) |

[a]Associations between cumulative exposure variables (from 1986, 1986/1988, and 1986/1988/1993) and later EDS (in 1988, 1993, and 1999) estimated on repeated measures by generalized estimating equations adjusted for baseline EDS (in 1986) and stratified sampling. The odds ratios represent estimates of new occurrence or reoccurrence of the relatively stable condition EDS and cannot be directly compared, in terms of absolute magnitude, with the odds ratios expressing cross-sectional associations.
[b]Rate includes subjects with moderately and severely impaired sleep quality (0 = not impaired, 1 = moderately impaired, 2 = severely impaired).
*p < .05.
**p < .01.
Abbreviation: BMI = body mass index.

years. In the multivariate analysis, the association between any anxiety disorders and later EDS persisted, while the other baseline variables did not remain significant predictors of EDS. Replacing the baseline insomnia diagnosis in 1979 and 1981 by the 5 baseline insomnia symptoms assessed in 1981 (trouble falling asleep, awakenings during sleep period, nocturnal anxiety states, waking up too early, trouble getting up in the morning) in the multivariate model of cumulative EDS between 1986 and 1999, confirmed once again that baseline insomnia symptoms were not significantly associated with later EDS.

Table 5 presents a longitudinal multivariate model on later EDS including major depression, any anxiety disorder, nocturnal sleep symptoms, and being overweight as predictor variables. After controlling for stratified sampling and EDS in 1986, waking up too early, impaired sleep quality, and any anxiety disorder were significant predictors of later EDS. Multivariate longitudinal models on the development of psychopathology, using EDS as cumulative exposure variable, revealed a trend for an association between EDS and the development of any anxiety disorder (OR = 1.5, 95% CI = 1.0 to 2.2, p = .07). Among the sleep-related covariates, only impaired sleep quality was a significant predictor of later anxiety disorders in this model (OR = 1.4, 95% CI = 1.0 to 1.8, p < .05). EDS did not predict later major depression (OR = 1.2, 95% CI = 0.8 to 1.9, p = .46); among the sleep-related covariates, only trouble falling asleep (OR = 1.6, 95% CI = 1.0 to 2.7, p < .05) was significantly associated with later major depression.

**Table 6. Associations Between Somatic Disturbances and Excessive Daytime Sleepiness in 1993**

| Somatic Disturbances[a] | Odds Ratio (95% CI) |
|---|---|
| Pain | 1.4 (1.0 to 2.1) |
| Back | 1.6 (1.2 to 2.0)*** |
| Respiration | 1.8 (1.3 to 2.5)*** |
| Heart | 2.0 (1.5 to 2.6)*** |
| Circulation | 2.4 (1.8 to 3.1)*** |
| Stomach | 2.1 (1.6 to 2.7)*** |
| Headache | 2.2 (1.6 to 2.9)*** |
| Allergies | 1.2 (0.9 to 1.6) |

[a]Somatic disturbances were defined by the presence of self-reported somatic symptoms during the past 12 months. There was no valid evaluation of organic causes of these symptoms.
***p < .001.

**Table 7. Associations Between Excessive Daytime Sleepiness and Impaired Quality of Life in Various Domains**

| Domain | Odds Ratio (95% CI) |
|---|---|
| Relationship to parents | 1.0 (0.6 to 1.6) |
| Relationship to friends | 1.4 (0.6 to 2.9) |
| Relationship to partner | 2.2 (1.3 to 2.6)** |
| Relationship to family | 1.5 (0.7 to 3.1) |
| Job, professional life | 1.8 (1.2 to 2.9)** |
| Physical well-being | 1.6 (1.0 to 2.4)* |
| Psychological well-being | 1.5 (1.0 to 2.3)* |

*p < .05.
**p < .01.

### Associations Between EDS and Somatic Disturbances and Quality of Life (Tables 6 and 7)

EDS was associated with various somatic symptoms including symptoms referable to the back, respiration, heart, circulation, stomach, and headache. However, pain and self-reported allergies were not associated with EDS. Table 7 shows that EDS was associated with impaired quality of life in terms of relationship to partner, job, and physical and psychological well-being. Quality of life with regard to relationships with parents, family, and friends appeared not to be related to EDS.



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## DISCUSSION

EDS was a common complaint among young adults in this study. Although the study sample was stratified, with an overrepresentation of risk cases for psychiatric disorders, prevalence rates were weighted back to the original representative population sample, suggesting that EDS is also a common complaint in the general adult population in this age range. EDS showed an increase in prevalence with age. The main cross-sectional correlates of EDS were nocturnal sleep symptoms. Longitudinally, waking up too early, impaired sleep quality, and anxiety were associated with later EDS. Finally, we found associations between EDS and being overweight, somatic disturbances, and impaired quality of life.

### Definition and Prevalence of EDS

Although there is growing evidence of the high clinical and societal importance of EDS, there is no established reference standard for subjective measures of sleepiness,[37] and the biological basis of various sleepiness phenomena such as state versus trait sleepiness, sleep propensity versus need of sleep, and uncontrolled sleepiness versus generalized fatigue have not yet been determined.[38] Prevalence rates ranging from 0.3%[39] to 43%[5] have been reported. Even within the same study, prevalence rates vary depending on the specific definition.

The prevalence rate found in the current study was 37.5% using cumulative 1-year prevalence rates from 4 interviews administered between the ages of 27 and 40 years. This rate is high relative to previous studies. The inclusion of items covering both propensity to fall asleep and need for sleep, the lack of a symptom duration criterion, the repeated assessment, and the stratification method used to build the follow-up sample may have contributed to this high prevalence rate. However, the relatively strong associations between EDS and impairment in quality of life are consistent with the practical utility of the EDS definition of the current study.

This study showed that the prevalence of EDS was higher in women than in men, and that the prevalence of EDS increased with age, specifically between the ages of 34 and 40 years. These results are in line with some previous studies showing higher EDS prevalence in women than in men,[7–9,32] and an increase in EDS with age,[8,40] although our study was conducted in a younger sample. Other studies showed higher EDS prevalence in men than in women,[10] no sex difference,[6,33,41] no age effect,[9] and a decrease of EDS with age.[7,32] Differences in recruitment methods and differences in EDS definitions may partly explain these inconsistencies.[42] In the current study, the sampling method and unidentified nonrandom missing data mechanisms may have additionally contributed to biased prevalence rates, although EDS was not directly associated with dropout.

### Associations Between EDS and Nocturnal Sleep Symptoms

This study showed strong cross-sectional associations between EDS and sleep symptoms. Trouble falling asleep, awakenings during sleep period, waking up too early, trouble getting up in the morning, nocturnal hypersomnia, and impaired sleep quality were significant correlates of EDS in both bivariate and multivariate analyses. Consistent with the associations between both insomnia symptoms and nocturnal hypersomnia and EDS, we found that the difference between desired and actual sleep duration was associated with EDS, regardless of whether subjects desired to sleep more or less than they actually did. Finally, the longitudinal associations between waking up too early, impaired sleep quality, and later EDS raise the possibility of a causal relationship, although other explanations (e.g., common diathesis or general increase in symptoms reporting) are also possible.

This study is in line with previous investigations demonstrating that subjective EDS is associated with subjective insomnia, particularly with difficulty initiating sleep, wakefulness after sleep onset, and post-sleep complaints.[7,8,33,41,43–45] These findings suggest that gross or subtle nocturnal sleep disturbances pose a risk factor for later onset of EDS. Given that nocturnal sleep symptoms are prevalent and potentially modifiable by means of pharmacologic and behavioral treatments, these findings may have important clinical implications for the prevention and treatment of EDS.[46] On the other hand, the association between nocturnal hypersomnia and EDS is in line with studies showing that total sleep time and sleep efficiency correlate with increased daytime sleep tendency in some individuals.[11,47] This suggests that these individuals suffer from a generally increased sleep drive.[38] These 2 apparently contradictory findings—that EDS is associated with both insomnia and nocturnal hypersomnia—suggest that EDS may arise from different mechanisms in different individuals. In the first case, EDS may represent "compensatory sleepiness" in response to sleep loss, whereas in the second case, EDS may represent a general tendency toward increased sleep propensity. Experimental studies among individuals with insomnia and nocturnal hypersomnia could help to clarify this possibility.

### Associations Between EDS and Psychiatric and Somatic Conditions

Anxiety disorders were consistently associated with EDS in the bivariate, multivariate, and longitudinal analyses. This suggests that anxiety may precede and potentially cause symptoms of EDS. In addition, anxiety may indirectly contribute to EDS by accounting for insomnia symptoms causing EDS, and anxiety may be a shared explanation for both nocturnal sleep disturbances and EDS.[12,13] Finally, there was a nonsignificant trend for EDS being associated with the development of anxiety disor-

ders, suggesting the potential for a common diathesis. Growing evidence implicates common brain neurotransmitters (e.g., serotonin, γ-aminobutyric acid, and neuropeptide Y) in anxiety disorders and in the regulation of the sleep-wake cycle.[48,49] Therefore, associations between EDS and anxiety are not surprising. However, interpreting the specific mechanisms on the basis of the current neurobiological understanding remains speculative. The preliminary finding of an association between a family history of phobic disorders and EDS (data not shown) being in line with a recent twin study on chronic fatigue[50] suggests that some portion of the anxiety-sleepiness association may be due to genetic covariation. Because anxiety disorders are prevalent and treatable conditions, these associations might have important clinical implications.

Several previous epidemiologic studies found cross-sectional associations between depression and EDS,[6–9] consistent with the current study. However, in the current study, the association between major depression and EDS was found only in the bivariate analysis. The multivariate analysis suggested the possibility, among others, that this association was mediated by sleep disorder symptoms[51] and comorbid anxiety, and the longitudinal analysis did not show associations between major depression and later EDS. Taken together, these findings suggest that major depression is only indirectly related to EDS.

Being overweight correlated with EDS in the bivariate and multivariate cross-sectional analyses, thus expanding results from previous clinical studies showing increased rates of EDS in severely obese subjects[34] to overweight subjects in a community sample. Because objective measures of sleep-disordered breathing were not included in the current study, we cannot address whether obstructive sleep apnea mediates this relationship.

In addition, a wide range of self-reported somatic disturbances was associated with EDS at a highly significant level. Whether these somatic complaints represented actual medical conditions or simply a tendency toward reporting physical complaints cannot be determined, since the current study did not include medical examinations. However, our findings are consistent with previous studies that found relatively specific associations between somatization and EDS[44] and unexplained fatigue.[52]

### EDS and Quality of Life

This study shows associations between EDS and impairments in quality of life with respect to job and partner, and between EDS and a low educational level. Previous studies associated EDS, regardless of its causes, with industrial and motor vehicle accidents, decreased productivity, reduced educational achievements, and interpersonal problems.[1,2,4,53–55] These findings along with the high prevalence of EDS imply a considerable public health impact of EDS.

### Limitations and Strengths

This study has several methodological limitations. The assessments of EDS, sleep characteristics, and body weight were based on self-report with a small number of questions, some of which were presented with dichotomous yes/no responses. No objective sleep measures were available to validate the self-reported data; therefore, subjects could have conflated fatigue and sleepiness as constructs. The inconsistent assessment of sleep characteristics in the interviews administered in 1979 and 1981 limited the evaluation of insomnia symptoms on EDS. Moreover, our definition of sleep duration did not subtract out wake time after sleep onset, and neither self-reported nor objective measures of sleep apnea as a potentially important correlate of EDS were available. These limitations in the assessment of sleep characteristics may have had the effect of placing relatively more emphasis on the role of anxiety disorders. Additional limitations may reduce the generalizability of the results. These include the inclusion of a single-age cohort, an attrition rate of 38%, and a sampling method that increased the probability of psychiatric disorders.

Nevertheless, the strengths of this study suggest the findings are worthy of further consideration. Specifically, the sample was community-based; the study design was longitudinal over 20 years; experienced, well-trained clinicians administered standardized interviews; and the main hypotheses (associations between EDS and sleep disorder symptoms, anxiety/depression, somatization, and quality of life) were associated with results found in larger community samples.

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