Subjective Daytime Sleepiness: Dimensions and Correlates in the General Population

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Study Objective: Discrepancies between several widely used assessment tools suggest that subjective daytime sleepiness is not a unitary phenomenon. Most research, however, has been based on patients. The aim of this study was to examine whether qualitatively different facets of subjective daytime sleepiness exist in the general population and to assess how different aspects of subjective sleepiness varied by age, gender, education status, body mass index, sleep debt, Stanford Sleepiness Scale, and objectively measured sleepiness (Multiple Sleep Latency Test).

Design: Cross-sectional study.

Setting and Participants: Population-based sample of 1562 women and 1351 men, mean age of 46.6 ± 7.9 years, including a subset of 145 participants who underwent an Multiple Sleep Latency Test.

Measurements: Self-reported sleepiness problems, Epworth Sleepiness Scale items, sleep habits, Multiple Sleep Latency Test, and Stanford Sleepiness Scale.

Results: Principal-axis factor analysis of 13 self-reported daytime-sleepiness measures yielded 3 factors, labeled perceived daytime sleepiness (Cronbach’s α = 0.74), subjective sleep propensity in active situations (α = 0.82), and subjective sleep propensity in passive situations (α = 0.63). The factor-based scores were all related to increased body mass index and lower education status, but the associations of scores for perceived and subjective propensity factors differed with gender, age, sleep debt, MSLT, and Stanford Sleepiness Scale. Worse perceived sleepiness factor-based score was significantly related to female gender, younger age, higher sleep debt, and worse Stanford Sleepiness Scale scores. Worse factor-based scores for subjective sleep propensity in both active and passive situations were significantly associated with male gender, older age, and worse Multiple Sleep Latency Test scores.

Conclusion: Findings from the present analysis on a general population sample support the hypothesis that subjective daytime sleepiness has multiple dimensions.

Key Words: Daytime sleepiness, gender, Epworth Sleepiness Scale, Multiple Sleep Latency Test, Stanford Sleepiness Scale, self-reported sleepiness problems

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INTRODUCTION

A MULTIDIMENSIONAL CONCEPT OF SLEEPINESS HAS BEEN THE TOPIC OF SEVERAL PUBLICATIONS WITH THE GOAL OF BETTER ASSESSMENT OF THE CONDITION OF EXCESSIVE daytime sleepiness. A concept of sleepiness as a function of homeostatic and circadian processes was proposed more than 20 years ago by Borbély; models proposed since then have stressed the competing drives of wake and sleep and have included consideration of situational and trait or exogenous factors. Although the relative importance of the components of sleepiness is somewhat controversial, the complexity of sleepiness and the difficult issues in defining and measuring specific aspects are widely acknowledged. The multidimensionality of sleepiness is supported by many studies showing poor correlations of sleepiness assessed with different measurement tools, as well as the lack of consistent associations of predictors of sleepiness, such as sleep apnea, with different measures of sleepiness. Most research on the dimensionality of sleepiness has focused on contrasting the specificity of objective measures of the tendency to fall asleep and of the failure to maintain wakefulness. Some patient-based and experimental studies have also shown poor agreement between objective and subjective measures. For example, in a study of sleep-deprived volunteers, the propensity to fall asleep in nap trials (eg, Multiple Sleep Latency Test [MSLT]) was not strongly correlated with subjective sleepiness, suggesting that measures of subjective sleepiness reflect something other than sleep drive.

Less is known, however, about whether tools that rely on self-report, ranging from questions on feelings of sleepiness and fatigue to subjective estimates of sleepy behavior, are able to measure distinct aspects of sleepiness. A better understanding of subjective measures of sleepiness is particularly important because objective measurement is not feasible in most population research and clinical assessment, particularly in primary care.

In the few studies conducted on this topic, only weak correlations between feelings of sleepiness and self-estimated sleepy behavior have been reported, suggesting there are distinct components of subjective sleepiness. Alternatively, subjective sleepiness may be inherently unidimensional. Responses to any type of question on sleepiness may predominantly stem from the overarching belief an individual holds regarding their sleepiness. This view, whereby behavior, expectations, and perceptions are integrated, is supported by studies that have found no evidence of multiple factors emerging from analyses of a wide range of sleepiness questions specific to adult and pediatric populations.
The aim of this study was to examine data from multiple measures of self-reported sleepiness collected in the Wisconsin Sleep Cohort Study (WSCS) for evidence of multidimensionality. We performed factor analysis on self-report data from commonly used questions on feelings of sleepiness and sleepy behavior, including items from the Epworth Sleepiness Scale (ESS), and compared correlations of the resulting factors with sociodemographic variables, predictors of sleepiness, and, on a subset, with measures of state sleepiness (Stanford Sleepiness Scale [SSS]) and objectively measured sleepiness (MSLT).

METHODS

Sample

A subset of the WSCS was analyzed for this investigation. The sample for the WSCS was constructed as follows: all employees, aged 30 to 60 years, of 5 state agencies in south central Wisconsin were initially surveyed in 1988 to create a defined sampling frame. Subjects were then recruited at the rate of approximately 5 per week from this sampling frame to undergo an extensive laboratory protocol that included an MSLT and the SSS. A weighted sampling scheme, with oversampling of habitual snorers, was used to increase variability in sleep-disordered breathing. When appropriate, the weighted sampling is accounted for in analyses. A complete description of the design of the WSCS is provided elsewhere. Over the years, follow-up mailed surveys and laboratory protocols have been conducted.

The sample for this study comprises 2913 WSCS respondents to a follow-up mailed survey on sleep habits, problems, and other factors, conducted in 1993, and a subset of these respondents (n = 145) who had in-laboratory studies conducted within 6 months (average = 3 months) of the completion of their survey. Study protocols and informed-consent documents were approved by the institutional review board of the University of Wisconsin Medical School.

MEASURES

Sleepiness Items

Thirteen items pertaining to daytime sleepiness from the survey conducted in 1993 were used. Respondent were asked to indicate the frequency of experiencing the following sleepiness problems: (1) feeling of excessive daytime sleepiness, (2) not feel rested during the day, no matter how many hours of sleep you had, (3) fall asleep or doze momentarily—at meetings, church, etc., (4) need for coffee or other stimulants to stay awake during the day, and (5) very difficult to get up in the morning. Response categories were: never (0/month), rarely (1/month), sometimes (2-4/month), often (5-15/month), or almost always (16-30/month). Each variable was scored on an ordinal scale (0-4). The other 8 items were self-reported sleepiness variables based on questions from the ESS. Using a response scale of 0 to 3 (never, slight, moderate, and high), respondents were asked how likely they would be to doze off or fall asleep in the following 8 situations, based on their usual way of life in recent times: (1) sitting and reading, (2) watching TV, (3) sitting inactive in a public place (e.g., a theater or a meeting), (4) as a passenger in a car for an hour without a break, (5) lying down when circumstances permit, (6) sitting and talking to someone, (7) sitting quietly after a lunch without alcohol, and (8) in a car while stopped for a few minutes in traffic.

Objective and State Sleepiness Measures

The MSLT was conducted in accordance with published guidelines, with 4 nap-opportunity trials, performed in a darkened bedroom, at 2-hour intervals. Each trial was terminated by the onset of electroencephalogram-determined sleep or after 20 minutes if sleep did not occur. The sleep latency for each nap trial was defined as the time to the first 30-second epoch with at least 15 seconds of any stage of sleep. The MSLT score was the average of sleep latency for the 4 trials. The SSS, a measure of self-reported feeling of the immediate state of sleepiness on a 7-point scale, ranging from “alert” (1) to “almost sleep” (7), was administered before each MSLT trial.

Age, Body Mass Index, Education Status, and Sleep Debt

Data on gender, age, body mass index (BMI), education status, and reported hours of sleep during usual workdays and non-workday nights from the survey were used. Highest education attainment, a surrogate for socioeconomic status, was measured with the question: What is the highest level of formal school you completed? Response categories were (1) less than high school, (2) high school, (3) some college, (4) college graduate, and (5) postcollege graduate. Reported hours of sleep during usual workday and nonworkday nights were measured with the questions: How many hours of sleep do you usually get during (1) a workday night and (2) a weekend/nonwork day night? Self-reported sleep debt was calculated by subtracting reported hours of sleep during workday from nonworkday night. Self-reported sleep debt is conceptualized as having unmet sleep needs and commonly quantified as the difference between weekend (or nonworkday) and weekday (or workday) hours of sleep, as sleep debt is accumulated during the week or workdays and expressed as increased sleep time during the weekend or nonworkdays.

Statistical Methods

Exploratory factor analysis was performed to identify interpretable constructs that explained the correlations among the measured self-reported sleepiness items. A principal-axis factor method was used to identify the smallest number of factors that together accounted for only the common variance in the reduced correlation matrix of the observed sleepiness variables. The oblique (promax) rotation technique, which allowed for the resulting factors to be interrelated, was used to obtain a simple and interpretable factor structure.

The number of factors to retain was based on the scree test and the substantive meaningfulness of the rotated factor solution. Sleepiness variables with factor loadings above ± 0.30 were grouped together as factors and were labeled on the basis of the interpretation of the loadings. The internal consistency reliability was evaluated by Cronbach’s α. All statistical analyses were performed with SAS statistical software (PC version 8.02; SAS Institute, Cary, NC). The SAS FACTOR procedure, with the prior communality estimates (PRIORS = SMC) option, was used for the exploratory factor analysis.

Factor-based scores for each factor were calculated for each individual by summing the raw scores for the relevant item responses. The subjective sleepiness factor-based scores, and the MSLT and SSS scores, were transformed to standard deviation.
units (z-scores) for subsequent analyses. Multiple regression analysis was used to estimate the relationships between the subjective sleepiness factors and age, gender, BMI, education status, and sleep debt. Multiple regression analysis was also used to assess the relative associations of the MSLT and SSS with the subjective sleepiness factors. For this, only the subset of the sample (n = 145) with a laboratory study within 6 months of completing the survey was used, and analyses were adjusted for the weighted sampling. Sixty-four subjects had performed the daytime study protocol before and 81 subjects after completing the sleep survey. Mean time between the daytime and the sleep-survey evaluation was 3.1 ± 1.7 months.

RESULTS

The complete data on 13 sleepiness items were available for 2913 subjects. The characteristics of the sample are shown in Table 1. The sample distribution of the 13 sleepiness items is shown in Table 2. Of particular note, the distribution of responses on some of the items were very skewed, with most people reporting a moderate or high chance of dozing when they lie down to rest, and more than 85% of the sample reporting that they are never likely to doze during conversations or in a car stopped in traffic.

Factor Analysis of the Subjective Sleepiness Variables

The evaluation of the scree plot from the factor analysis showed a steep decline from the first factor and a leveling off at the fourth factor. Since factors 4 through 13 appeared after the last largest break, the first 3 factors were retained. The observed sleepiness variables were grouped together according to their highest factor loading (Table 3). Each subjective sleepiness variable loaded greater than ±0.30 on at least 1 factor, except for the “likely to doze while lying down to rest in the afternoon when circumstances permit” variable.

To determine the stability of the subjective sleepiness factors, a split-half design was applied. To this end, the derivation sample was randomly split into 2 subsamples (n = 1456 and 1457), and factor analysis was performed on both subsamples. Because the results showed no discernable differences in the number of factors to retain and the factor structure between the split samples, the factor analysis results from the entire sample were used.

The first factor was defined by very high loadings on items that related to self-reported perceived daytime sleepiness (PERCEIVED). The 5 items depicted “feelings of not being rested regardless of hours slept” and “difficulty getting up in the morning,” “feeling of excessive sleepiness,” and “need for coffee to stay awake.” The items had good internal consistency reliability, with a coefficient of 0.74.

Table 2 — Sample Distribution of Subjective Sleepiness Items in 2,913 Subjects

<table>
<thead>
<tr>
<th>Item</th>
<th>Response</th>
<th>Mean(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Not feeling rested during the day no matter how many hours of sleep you had*</td>
<td>0 1 2 3 4</td>
<td>7 35 36 16 6</td>
</tr>
<tr>
<td>2. Feeling excessive daytime sleepiness*</td>
<td>10 40 36 11 3</td>
<td>1.57 (0.92)</td>
</tr>
<tr>
<td>3. Great difficulty getting up in the morning*</td>
<td>16 40 30 10 4</td>
<td>1.46 (1.00)</td>
</tr>
<tr>
<td>4. Need for coffee or other stimulants to stay awake during the day*</td>
<td>34 28 21 11 6</td>
<td>1.25 (1.19)</td>
</tr>
<tr>
<td>5. Falling asleep or dozing momentarily at meetings, church, etc.*</td>
<td>45 32 17 5 1</td>
<td>0.84 (0.98)</td>
</tr>
<tr>
<td>6. Sitting and reading†</td>
<td>18 44 26 12</td>
<td>1.33 (0.90)</td>
</tr>
<tr>
<td>7. Watching TV†</td>
<td>11 41 33 15</td>
<td>1.52 (0.88)</td>
</tr>
<tr>
<td>8. Sitting inactive in a public place†</td>
<td>45 40 12 3</td>
<td>0.74 (0.79)</td>
</tr>
<tr>
<td>9. As a passenger in a car for an hour without a break†</td>
<td>27 41 20 12</td>
<td>1.17 (0.96)</td>
</tr>
<tr>
<td>10. Lying down to rest in the afternoon when circumstances permit†</td>
<td>9 25 29 37</td>
<td>1.94 (0.98)</td>
</tr>
<tr>
<td>11. Sitting and talking to someone†</td>
<td>85 13 1 1</td>
<td>0.16 (0.42)</td>
</tr>
<tr>
<td>12. Sitting quietly after a lunch without alcohol†</td>
<td>48 36 13 3</td>
<td>0.72 (0.82)</td>
</tr>
<tr>
<td>13. In a car while stopped for a few minutes in traffic†</td>
<td>88 10 1 1</td>
<td>0.14 (0.41)</td>
</tr>
</tbody>
</table>

*Item responses (frequency per month): 0 = never, 1 = rarely (once), 2 = sometimes (2-4), 3 = often (5-15), 4 = almost always (16-30).†Epworth Sleepiness Scale items (likely to doze off in specific situations): 0 = never, 1 = slightly, 2 = moderate, 3 = high.

Data are shown as percentage, unless otherwise indicated.
The second factor was referred to as subjective sleep propensity in active situations (PROPENSITY-ACTIVE) due to the similarities in the items in depicting subjective propensity to fall asleep or doze off in active environments in which falling asleep is generally inappropriate. All 6 items tapped into the likelihood of dozing in public or active situations such as “in a car,” “in meetings,” “while sitting in a public place,” and “sitting and talking.” The composite of the 7 items showed a good reliability coefficient of 0.81.

The third factor was referred to as subjective sleep propensity in passive situations (PROPENSITY-PASSIVE) because of the likeness in the 3 measures that portrayed the chance of falling asleep or dozing off in situations that were passive or highly soporific in which falling asleep is generally appropriate. The variables portrayed self-reported estimates of the propensity to fall asleep and doze while “watching TV,” “sitting and reading,” and “lying down to rest when circumstances permit,” which are behaviors commonly manifested in quiet environments. Despite the factor loading of the “lying down to rest when circumstances permits” variable (0.26) being marginally below the cutoff point of ± 0.30, it was included in the PROPENSITYPASSIVE subjective sleepiness factor due to the substantive meaningfulness as it relates to the other 2 variables. The composite of the 3 measures showed a satisfactory reliability coefficient of 0.63. The correlations between the subjective sleepiness factors were low to moderate (range, 0.29 - 0.59).

We used common factor analysis, instead of principal components analysis, for this study to identify the smallest number of factors that account for only the common variances of the subjective sleepiness variables. To this end, the rules for retaining relevant factors based on the scree test and the meaningfulness of the factor structure, which are appropriate in common factor analysis and differs from principal components analysis (ie, eigenvalue > 1 and percentage of variance explained), were used. The discernable scree test and the meaningfulness of the factor structure provided evidence of a 3-factor model of subjective daytime sleepiness.

### Relationships Between Subjective Sleepiness Factors and Covariates

The association of gender, age, BMI, education status, and sleep debt with each factor is shown in Figure 1. Since we did not see a dose-response relationship between the highest education attainment based on 5 categories and the subjective sleepiness factors, we dichotomized the responses to create a variable with categories of college graduate and not a college graduate to be used in our analysis.

Female gender (coefficient of gender β = 0.19, P < .0001), younger age (coefficient of 5-year change in age β = - 0.11, P < .0001), higher BMI (coefficient of 2-unit change in BMI β = 0.03, P < .0001), lower education status (coefficient of highest education attainment for college graduate vs not β = - 0.12, P = .002) were significantly related to worse PERCEIVED subjective sleepiness factor based scores. Male gender (coefficient of gender β = - 0.18, P < .0001), older age (coefficient of 5-year change in age β = 0.03, P = .028), higher BMI (coefficient of 2-unit change in BMI β = 0.03, P < .0001) were significantly related to worse PROPENSITY-ACTIVE subjective sleepiness factor score. In addition, male gender (coefficient of gender β = - 0.12, P = .001),

### Table 3—Factor Analysis With Oblique Rotation of the Subjective Sleepiness Variables in 2,913 Subjects

<table>
<thead>
<tr>
<th>Factor grouping/item</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Perceived daytime sleepiness</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Not rested during the day no matter how many hours of sleep you had</td>
<td>0.74†</td>
<td>-0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>3. Feeling of excessive daytime sleepiness</td>
<td>0.71†</td>
<td>0.08</td>
<td>0.03</td>
</tr>
<tr>
<td>2. Great difficulty getting up in the morning</td>
<td>0.62†</td>
<td>-0.06</td>
<td>-0.05</td>
</tr>
<tr>
<td>5. Need for coffee, or other stimulants to stay awake during the day</td>
<td>0.44†</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>II. Subjective sleep propensity in active situations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Likely to doze off while sitting and talking to someone</td>
<td>-0.05</td>
<td>0.68†</td>
<td>-0.06</td>
</tr>
<tr>
<td>13. Likely to doze off in a car while stopped for a few minutes in traffic</td>
<td>0.01</td>
<td>0.63†</td>
<td>-0.12</td>
</tr>
<tr>
<td>8. Likely to doze off while sitting inactive in a public place (eg, a theater or a meeting)</td>
<td>-0.04</td>
<td>0.62†</td>
<td>0.24</td>
</tr>
<tr>
<td>4. Fall asleep or doze momentarily—at meetings, church, etc.</td>
<td>0.03</td>
<td>0.61†</td>
<td>0.13</td>
</tr>
<tr>
<td>12. Likely to doze off while sitting quietly after lunch without alcohol</td>
<td>0.05</td>
<td>0.51†</td>
<td>0.18</td>
</tr>
<tr>
<td>9. Likely to doze off as a passenger in a car for an hour without a break</td>
<td>0.10</td>
<td>0.36†</td>
<td>0.22</td>
</tr>
<tr>
<td><strong>III. Subjective sleep propensity in passive situations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Likely to doze off while watching TV</td>
<td>-0.05</td>
<td>-0.05</td>
<td>0.71†</td>
</tr>
<tr>
<td>6. Likely to doze off while sitting and reading</td>
<td>-0.01</td>
<td>0.06</td>
<td>0.69†</td>
</tr>
<tr>
<td>10. Likely to doze while lying down to rest in the afternoon when circumstances permit</td>
<td>0.15</td>
<td>0.14</td>
<td>0.26†</td>
</tr>
</tbody>
</table>

Cronbach’s α

- 0.74 0.81 0.63

<table>
<thead>
<tr>
<th>Factor Intercorrelation</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Perceived Daytime Sleepiness</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Subjective Sleep Propensity-Active Situations</td>
<td>0.36*</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>III. Subjective Sleep Propensity-Passive Situations</td>
<td>0.29*</td>
<td>0.59*</td>
<td>-</td>
</tr>
</tbody>
</table>

*P < .05
†Items were retained on the respective factor.
Results from multiple regression analyses with sleep debt included in the models: Age refers to 5-year change in age; BMI, 2-unit change in BMI. All relationships were statistically significantly; P value < .05, except for education status and sleepy behavior-active sleepiness factor. Perceived refers to perceived daytime sleepiness factor; active, subjective sleep propensity in active situations factor; passive, subjective sleep propensity in passive situations factor.

older age (coefficient of 5-year change in age $\beta = 0.04$, $P = .025$), higher BMI (coefficient of 2-unit change in BMI $\beta = 0.03$, $P < .0001$), and lower education status (coefficient of highest education attainment for college graduate vs not $\beta = -0.17$, $P = .002$) were significantly related to worse PROPENSITY-PASSIVE subjective sleepiness factor score. The total $R^2$ values for the PERCEIVED, PROPENSITY-ACTIVE, PROPENSITY-PASSIVE models were 0.09, 0.02, and 0.03, respectively.

**Relationships Between Subjective Sleepiness Factors and Sleep Debt**

The association of sleep debt with the subjective sleepiness factors, adjusted for gender, age, education status, and BMI, is shown in Figure 2. Sleep debt was significantly related, in a dose-response manner, to worse PERCEIVED (coefficient of 1-hour increase in sleep debt $\beta = 0.15$, $P < .0001$), PROPENSITY-ACTIVE (coefficient of 1-hour increase in sleep debt $\beta = 0.08$, $P < .0001$), and PROPENSITY-PASSIVE (coefficient of 1-hour increase in sleep debt $\beta = 0.05$, $P < .0001$) subjective sleepiness factor scores.

**Relationships Between Subjective Sleepiness Factors and Measures From the Laboratory Subsample**

A description of the characteristics of the subsample of 145 participants with laboratory studies within 6 months of the survey is given in Table 4. The subsample participants are slightly older, have higher BMI, and a higher proportion of men, compared with the overall sample. These differences reflect the weighted sampling, as mentioned in the methods section. However, as is commonly done with analyses of stratified weighted sampling data, we accounted for the weighting in the regression models and found that the weighting did not affect the associations of covariates with the factors. The relationships between MSLT score and each subjective sleepiness factor, adjusted for gender, age, education status, BMI, and sleep debt, are shown in Figure 3. Lower MSLT score was significantly related to worse PROPENSITY-ACTIVE (standardized coefficient of MSLT $\beta = -0.29$, $P = .006$) and PROPENSITY-PASSIVE (standardized coefficient of MSLT $\beta = -0.26$, $P = .003$) subjective sleepiness factor scores, but not with PERCEIVED subjective sleepiness factor score (standardized coefficient of MSLT $\beta = -0.02$, $P = .806$). The total $R^2$ values for the PERCEIVED, PROPENSITY-ACTIVE, PROPENSITY-PASSIVE models were 0.06, 0.08, and 0.09, respectively.

**Relationships Between Subjective Sleepiness Factors and SSS**

The multiple regression coefficients reflecting the relationships between SSS score and each subjective sleepiness factor, adjusted for gender, age, education status, BMI, and sleep debt, are shown in Figure 4. Higher SSS score was significantly related to worse PERCEIVED subjective sleepiness factor score (standardized coefficient of SSS $\beta = 0.24$, $P < .001$), but not with PROPENSITY-ACTIVE (coefficient of SSS $\beta = 0.18$, $P = .058$) and PROPENSITY-PASSIVE (coefficient of SSS $\beta = 0.12$, $P = .147$) subjective sleepiness factor scores. The total $R^2$ values for the PERCEIVED, PROPENSITY-ACTIVE, PROPENSITY-PASSIVE models were 0.13, 0.05, and 0.04, respectively.

**DISCUSSION**

The primary aim of this study was to investigate the dimensionality of subjective sleepiness in often-utilized self-report measures of sleepiness in the general population. The findings
Figure 2—Relationship between sleep debt and subjective sleepiness factors in 2,913 subjects
Sleep debt refers to the reported hours of sleep on nonworkdays minus the hours of sleep on workdays. β refers to the regression coefficient of sleep debt, adjusting for gender, age, education status, and body mass index from multiple regression analysis. *Significantly different from 0 mean hours of sleep debt category. †Least square means adjusting for gender, age, education status, and body mass index.
but not in a patient-based study. In some studies, women, compared with men, reported more sleepiness regardless of hours of sleep, but scored lower on the ESS. In other studies, women, compared with men, reported greater feelings of being unrested regardless of menopausal status or use of hormone therapy, women, compared with men, being more likely to report perceived daytime sleepiness, but much less likely to report sleepy behavior in active or passive situations. This gender difference is in accord with results from many previous studies. In the only population-based study assessing both sleepy feelings and sleepy behavior, Baldwin et al.24 showed that women, compared with men, reported greater feelings of being unrested regardless of hours of sleep, but scored lower on the ESS. In other studies, women, compared with men, reported more sleepiness complaints,18,49 including feelings of excessive daytime sleepiness and feeling unrefreshed in the morning.50 In addition, reports of lower ESS scores by women have been shown in a community study of older people51 but not in a patient-based study.18 These findings may be explained by a stronger basic wake drive in women, resulting in less sleepy behavior and more feelings of excessive daytime sleepiness without sleep onset. There are also objective data in support of a basic gender difference in the sleep-wake drive. In a previous analysis of data from the WSCS, Punjabi et al.52 reported significantly lower MSLT scores in men compared with women.

However, there are several alternative explanations for a gender effect, based on other factors that influence self-report. Compared with men, women may be more sensitive to sleepy feelings or be more willing to report them, and less likely to report dozing. It is possible that midlife changes, in particular, increase awareness of sleep complaints in women. However, in an analysis of data on menopausal status available from laboratory studies on a subset of our sample (369 women, 1274 men), we found that, regardless of menopausal status or use of hormone therapy, women, in comparison with men, scored higher on the PERCEIVED and lower on the 2 subjective PROPENSITY sleepiness factors.

Age was differently related to the PERCEIVED and 2 subjective PROPENSITY sleepiness factors. The results are consistent with previous findings of associations with younger age and increased excessive daytime sleepiness in a general population sample ranging in age from 20 to 45 years.50 However, our findings also showed older subjects reporting a greater tendency to doze off, particularly in situations that were passive. It is possible that processes underlying the components of sleepiness, particularly circadian factors, change with age, resulting in more sleepy behavior during the daytime.53 Indeed, fragmented wake as well as fragmented sleep have been observed in older populations in nursing home settings.54 However, the age range in our sample (35-74 years) did not have a large number of subjects in the older age range. It is possible that reduced child rearing responsibilities and lifestyle differences over middle age may explain some of the age effect on our subjective sleepiness factors. In addition, the association between older age and sleepy behavior in passive situations may be due to the increased opportunities for older persons to place themselves voluntarily in highly soporific situations, such as watching TV or taking leisurely rests. Cultural influences on behavior may also be important: in active situations, such as

**Figure 3**—Relationship between Multiple Sleep Latency Test results and subjective sleepiness factors in 145 subjects.

*Multiple regression coefficient adjusting for gender, age, education status, body mass index, and sleep debt. **P value < .05. Vertical bars indicate 95% confidence intervals.

**Figure 4**—Relationship between Stanford Sleepiness Scale scores and subjective sleepiness factors in 145 participants.

*Multiple regression coefficient adjusting for gender, age, education status, body mass index, and sleep debt. **P value < .05. Vertical bars indicate 95% confidence intervals.

The associations of gender with the factors were strikingly different, with women, compared with men, being more likely to report perceived daytime sleepiness, but much less likely to report sleepy behavior in active or passive situations. This gender difference is in accord with results from many previous studies. In the only population-based study assessing both sleepy feelings and estimates of sleepy behavior, Baldwin et al.24 showed that women, compared with men, reported greater feelings of being unrested regardless of hours of sleep, but scored lower on the ESS. In other studies, women, compared with men, reported more sleepiness complaints,18,49 including feelings of excessive daytime sleepiness and feeling unrefreshed in the morning.50 In addition, reports of lower ESS scores by women have been shown in a community study of older people51 but not in a patient-based study.18 These findings may be explained by a stronger basic wake drive in women, resulting in less sleepy behavior and more feelings of excessive daytime sleepiness without sleep onset. There are also objective data in support of a basic gender difference in the sleep-wake drive. In a previous analysis of data from the WSCS, Punjabi et al.52 reported significantly lower MSLT scores in men compared with women.

However, there are several alternative explanations for a gender effect, based on other factors that influence self-report. Compared with men, women may be more sensitive to sleepy feelings or be more willing to report them, and less likely to report dozing. It is possible that midlife changes, in particular, increase awareness of sleep complaints in women. However, in an analysis of data on menopausal status available from laboratory studies on a subset of our sample (369 women, 1274 men), we found that, regardless of menopausal status or use of hormone therapy, women, in comparison with men, scored higher on the PERCEIVED and lower on the 2 subjective PROPENSITY sleepiness factors.

Age was differently related to the PERCEIVED and 2 subjective PROPENSITY sleepiness factors. The results are consistent with previous findings of associations with younger age and increased excessive daytime sleepiness in a general population sample ranging in age from 20 to 45 years.50 However, our findings also showed older subjects reporting a greater tendency to doze off, particularly in situations that were passive. It is possible that processes underlying the components of sleepiness, particularly circadian factors, change with age, resulting in more sleepy behavior during the daytime.53 Indeed, fragmented wake as well as fragmented sleep have been observed in older populations in nursing home settings.54 However, the age range in our sample (35-74 years) did not have a large number of subjects in the older age range. It is possible that reduced child rearing responsibilities and lifestyle differences over middle age may explain some of the age effect on our subjective sleepiness factors. In addition, the association between older age and sleepy behavior in passive situations may be due to the increased opportunities for older persons to place themselves voluntarily in highly soporific situations, such as watching TV or taking leisurely rests. Cultural influences on behavior may also be important: in active situations, such as...
public gatherings, older people may not be as susceptible to the masking effects of the environment to stay alert as are younger people.

Correlations with education status and BMI were similar for all 3 subjective sleepiness factors. Low education status, as a marker for low socioeconomic status, has been reported as a predictor for daytime sleepiness. However, given the potential differences in interpretation of survey questions and degree of stigma associated with dozing behavior or complaining of sleepiness by socioeconomic status, we expected differences in the way sleepiness was expressed. The lack of difference in correlations by factor indicates that the sum effect of social factors affecting how sleepiness is reported may be fairly small. We also found that higher BMI was weakly associated with all 3 factors of subjective daytime sleepiness. The association of increased BMI and sleepiness has been widely reported, with causality in both directions proposed. Since BMI is an important correlate of sleep apnea, a condition associated with daytime sleep attacks, it is interesting that BMI was not a stronger predictor of self-reported dozing behavior than of sleepy feelings.

Most importantly, although strengths of association varied, sleep debt was a predictor for all 3 sleep factors, indicating that all 3 factors were related to a basic sleep drive to some extent. Sleep debt, an indicator of insufficient sleep, has been shown to be associated with perceived daytime sleepiness in experimental and population-based studies. Our results concur, but we further found that sleep debt was even more strongly related to the perceived daytime sleepiness construct compared to the constructs of subjective sleep propensity. Attempts to make up for too little sleep during workdays do not appear to ameliorate the feelings of sleepiness. Neither subjective PROPENSITY sleepiness factor showed a dose-response association with sleep debt, but the regression coefficient was lowest for subjective PROPENSITY-PASSIVE. Similar to the relationship of age and subjective sleep propensity, it is possible that people who are most likely to doze in passive situations, eg, lying down to rest, may have different lifestyles that do not lead to restricted sleep during the work week.

Our findings of a significant association between the MSLT and both PROPENSITY-ACTIVE and PROPENSITY-PASSIVE subjective sleepiness factors are consistent with a previous report from the WSCS showing a moderate relationship between the MSLT and the ESS. Using a multivariable proportional hazards model, Punjabi et al’s study showed that, compared with individuals in the lowest ESS quartile (<6), those in the intermediate (6-11) and highest (≥12) ESS quartiles had a 30% and 69%, respectively, increased risk for sleep onset during the MSLT. The findings are also congruous with results from other studies showing a significant relationship between the MSLT and the excessive daytime sleepiness factor representing the tendency to fall asleep in inappropriate times and ESS scores. The correlation of the MSLT with the 2 self-reported PROPENSITY sleepiness factor and not the PERCEIVED sleepiness factor, seen in this study, supports the validity of distinct subjective sleepiness factors.

Interestingly, although all factors were related to SSS, only the association with PERCEIVED was statistically significant, and the strength of the association was lowest for subjective PROPENSITY-PASSIVE sleepiness factor. The association between the SSS, as a measure of immediate feelings of sleepiness, and PERCEIVED subjective sleepiness factor suggests that the PERCEIVED sleepiness factor, while based primarily on questions of chronic sleepy feelings, also reflects state sleepiness. Alternatively, state sleepiness may affect reporting of usual behavior, whereby individuals’ current conditions influence their recall of the past, a common problem in interpreting self-report data. It is interesting that, although not statistically significant, less state sleepiness is associated with propensity to fall asleep in passive compared with active situations, suggesting that the 2 factors do differ on severity.

The present study has some limitations. Our main analysis was restricted to participants in our 1993 survey, and not all of these participants had laboratory studies within an acceptable timeframe. For analysis of the relationship of the subjective sleepiness factors with the MSLT and SSS, we included subjects who had a laboratory study within 6 months of completing the survey (n = 145). Thus, the MSLT and SSS data were not collected at the same time as the survey data. It is possible that events occurring in the interval (average of 3 months) may have resulted in MSLT and SSS measures that differed from what would have been recorded at the time of the survey data. This would introduce random variability, or noise, and would tend to weaken the strength of the associations. However, we investigated the influence of the time interval between the survey and laboratory data collection and found no difference in results.

Also, we did not have current data on whether participants were working night or rotating shifts at the time they completed the survey. Although at one point we estimated that 10% of our overall sample did have a shiftwork schedule, this varied over time. Nightshift workers, compared with dayshift workers, are likely to be at a greater risk of sleepiness, and it would have been interesting to investigate whether our factors discriminated shiftwork. Based on the shiftwork data collected at other times (within 4 years of the sleep survey), we approximated the associations between shiftwork status and the subjective sleepiness factors. Of the 2913 subjects, 266 (9%) reported working the nightshift at some time. We found that nightshift workers, compared with dayshift workers, had consistent and statistically significant worse scores on all the subjective sleepiness factor scores. The results concur with previous findings of an association between nightshift work and subjective sleepiness.

Despite being statistically significant, the overall predictive power of the covariates for the subjective sleepiness factors was limited. Most of the variance in the subjective sleepiness factors remains unexplained by our models, which included age, gender, BMI, education status, and sleep debt. Clearly, there are other key determinants of subjective sleepiness, but measurement error within the subjective sleepiness factors, calculated from individual categorical responses, may also explain the lower explanatory power to the unexplained variance. However, our intention was not to determine what best explains subjective sleepiness, but rather, to examine whether and how the factors differed with respect to basic characteristics, sleep debt, the MSLT, and the SSS.

The findings from this study imply that measuring both feelings of sleepiness as well as self-estimated sleep behavior are important when investigating occurrence, etiologies, and consequences of daytime sleepiness. Our data, furthermore, suggest that questions on sleep behavior in a passive setting, exclusive of sleepiness in an active setting, may occur, at least in part, with voluntarily unopposed wake drive and may not necessarily reflect problem sleepiness. More research to better measure and understand the difference in intentional and unwanted sleepiness.
in passive situations is needed. Daytime sleepiness should not be dismissed on the basis of scales or questions that reflect only one of these aspects. As shown in this and another study,24 daytime sleepiness in women, compared with men, is not likely to be reported as sleepy behavior. Thus, the ESS, with questions that pertain only to reported sleepy behavior, may fail to identify sleepy women.

In conclusion, subjective daytime sleepiness is multifaceted, and self-report tools can measure at least 2 distinct aspects. Our findings of distinct factors of subjective sleepiness may provide a framework for defining subjective sleepiness for future research. Given the distinction between the subjective sleepiness dimensions of feelings of sleepiness and self-estimated sleep behavior and the likelihood that both are valid measures of significant sleepiness, the inclusion of questions that tap both aspects are needed in research and clinical settings that rely on self-report to assess sleepiness.

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REFERENCES


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52. Punjani N, Bandeen-Roche K, Young T. Predictors of objective sleep tendency in the general population. Sleep 2003;26:678-83.
59. Åkerstedt T. Sleepiness as a consequence of shift work. Sleep 1988;11:17-34.