Table 2
Proportions and mean PGC Morale Scale scores of participants according to attributes and sleep-related items

| Items | Category | Percentage of category (%) | Comparison of PGC scores | | | |
|---|---|---|---|---|---|---|
| | | | Mean ± SD | | *p*-value | |
| Age (year) | 70–74 | 42.2 | 8.59 | 2.4 | <0.001 | #1(KW) |
| | 75–79 | 30.7 | 8.35 | 2.5 | | |
| | 80–84 | 18.3 | 8.13 | 2.5 | | |
| | 85+ | 8.9 | 7.88 | 2.6 | | |
| Gender | Women | 54.9 | 8.14 | 2.6 | 0.003 | #2 |
| | Men | 45.1 | 8.50 | 2.4 | | |
| Sleep duration (hours) | <6 | 9.6 | 7.82 | 3.0 | #3 | #1(MC) |
| | 6–7 | 17.9 | 8.48 | 2.4 | | |
| | 7–8 | 22.5 | 8.68 | 2.4 | | |
| | 8–9 | 30.7 | 8.60 | 2.3 | | |
| | 9+ | 19.4 | 8.01 | 2.6 | | |
| Place of residence | Urban | 62.4 | 8.37 | 2.5 | 0.1991 | #2 |
| | Rural | 37.6 | 8.22 | 2.5 | | |
| Educational history | Junior high school | 60.0 | 8.07 | 2.6 | <0.001 | #1(KW) |
| | High school | 30.8 | 8.59 | 2.3 | | |
| | Vocational school/College | 2.9 | 8.81 | 2.3 | | |
| | University | 6.3 | 9.16 | 2.3 | | |
| Physical pain | Yes | 32.9 | 7.56 | 2.7 | <0.001 | #2 |
| | No | 67.1 | 8.76 | 2.3 | | |
| Psychological stress | Yes | 23.3 | 6.55 | 2.9 | <0.001 | #2 |
| | No | 76.7 | 8.91 | 2.2 | | |
| Subjective sleep sufficiency | Very sufficient | 51.0 | 8.93 | 2.1 | #4 | #1(MC) |
| | Sufficient | 38.7 | 8.20 | 2.6 | | |
| | Insufficient | 9.6 | 6.61 | 3.0 | | |
| | Very insufficient | 0.7 | 5.75 | 3.3 | | |
| Difficulty initiating sleep (DIS) | Yes | 35.4 | 7.37 | 2.8 | <0.001 | #2 |
| | No | 64.6 | 8.79 | 2.2 | | |
| Difficulty maintaining sleep (DMS) | Yes | 63.1 | 8.19 | 2.6 | <0.001 | #2 |
| | No | 36.9 | 8.84 | 2.3 | | |
| Early morning awakening (EMA) | Yes | 34.0 | 7.74 | 2.8 | <0.001 | #2 |
| | No | 66.0 | 8.70 | 2.2 | | |
| Sleep enhancing medication use (SEMU) | Yes | 19.0 | 7.25 | 2.9 | <0.001 | #2 |
| | No | 81.0 | 8.51 | 2.4 | | |
| Excessive daytime sleepiness (EDS) | Yes | 40.7 | 7.83 | 2.7 | <0.001 | #2 |
| | No | 59.3 | 8.54 | 2.4 | | |
| Restless legs syndrome (RLS) | Yes | 11.4 | 6.87 | 2.9 | <0.001 | #2 |
| | No | 88.6 | 8.50 | 2.4 | | |
| Self-rated health | Good | 30.8 | 9.31 | 2.2 | <0.001 | #1(KW) |
| | Fair | 42.8 | 8.66 | 2.1 | | |
| | Poor | 26.4 | 6.78 | 2.8 | | |

#1:Kruskal–Wallis test(KW) and Wilcoxon rank-sum test with Bonferroni's correction for multiple comparison(MC).
#2:Wilcoxon rank-sum test.
#3: Refer to Fig. 2.
#4: Refer to Fig. 1.

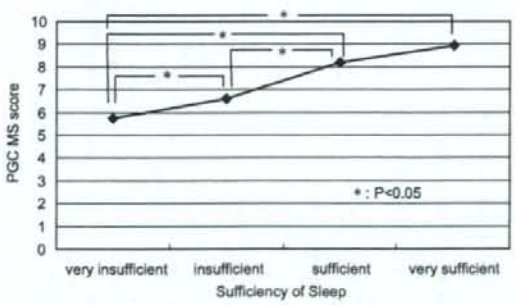


Fig. 1. Mean values of PGC Morale Scale scores according to the level of subjective sleep sufficiency.

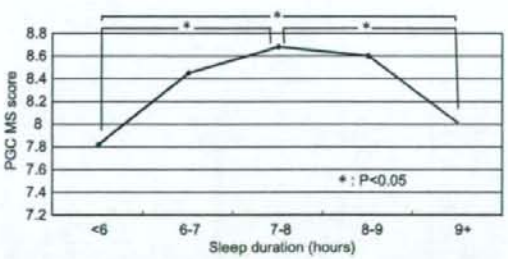


Fig. 2. Mean values of PGC Morale Scale scores according to sleep duration.

Table 3
Analysis of association between the PGC Morale Scale scores and sleep-related items using logistic regression analysis $

| Items | Category | Crude | | | | Adjusted (Model 1)#1 | | | | Adjusted (Model 2)#2 | | | | Adjusted (Model 3)#3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Odds ratio | 95%CI‡ | | p-value | Odds ratio | 95%CI | | p-value | Odds ratio | 95%CI | | p-value | Odds ratio | 95%CI | | p-value |
| | | | lower | upper | | | lower | upper | | | lower | upper | | | lower | upper | |
| Age (year) | 70–74 | 1.000§ | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| | 75–79 | 1.010 | 0.817 | 1.248 | 0.926 | 1.014 | 0.797 | 1.290 | 0.911 | 1.012 | 0.794 | 1.291 | 0.923 | 1.057 | 0.824 | 1.356 | 0.661 |
| | 80+ | 0.718 | 0.560 | 0.922 | 0.009 | 0.801 | 0.602 | 1.066 | 0.129 | 0.780 | 0.584 | 1.040 | 0.091 | 0.814 | 0.605 | 1.095 | 0.173 |
| Gender | Women | 0.814 | 0.676 | 0.980 | 0.029 | 1.076 | 0.864 | 1.340 | 0.511 | 1.075 | 0.862 | 1.341 | 0.521 | 1.051 | 0.837 | 1.319 | 0.669 |
| | Men | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Sleep duration (hours) | <6 | 0.499 | 0.376 | 0.663 | <0.001 | 0.867 | 0.580 | 1.296 | 0.487 | 1.051 | 0.692 | 1.595 | 0.817 | 1.056 | 0.688 | 1.621 | 0.804 |
| | 6–7 | 0.721 | 0.572 | 0.910 | 0.006 | 0.997 | 0.719 | 1.382 | 0.984 | 1.056 | 0.759 | 1.471 | 0.745 | 1.027 | 0.732 | 1.440 | 0.878 |
| | 7–8 | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| | 8–9 | 0.941 | 0.765 | 1.159 | 0.569 | 0.932 | 0.696 | 1.247 | 0.634 | 0.932 | 0.696 | 1.248 | 0.637 | 0.932 | 0.691 | 1.257 | 0.647 |
| | 9+ | 0.632 | 0.497 | 0.803 | <0.001 | 0.649 | 0.465 | 0.907 | 0.011 | 0.653 | 0.467 | 0.913 | 0.013 | 0.729 | 0.516 | 1.031 | 0.074 |
| Place of residence | Urban | 0.771 | 0.661 | 0.900 | 0.001 | 0.902 | 0.719 | 1.132 | 0.372 | 0.875 | 0.696 | 1.099 | 0.251 | 0.881 | 0.697 | 1.114 | 0.289 |
| | Rural | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Educational history | by 1 step | 1.319 | 1.174 | 1.483 | <0.001 | 1.306 | 1.137 | 1.499 | <0.001 | 1.285 | 1.118 | 1.478 | <0.001 | 1.242 | 1.076 | 1.434 | 0.003 |
| Physical pain | Yes | 0.436 | 0.371 | 0.514 | <0.001 | 0.646 | 0.512 | 0.815 | <0.001 | 0.667 | 0.527 | 0.844 | 0.001 | 0.825 | 0.645 | 1.056 | 0.127 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Psychological stress | Yes | 0.209 | 0.171 | 0.255 | <0.001 | 0.241 | 0.184 | 0.316 | <0.001 | 0.252 | 0.192 | 0.331 | <0.001 | 0.274 | 0.207 | 0.363 | <0.001 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Difficulty initiating sleep(DIS) | Yes | 0.580 | 0.505 | 0.420 | <0.001 | 0.612 | 0.477 | 0.787 | <0.001 | 0.627 | 0.487 | 0.808 | <0.001 | 0.622 | 0.480 | 0.807 | <0.001 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Difficulty maintaining sleep(DMS) | Yes | 0.531 | 0.451 | 0.626 | <0.001 | 0.929 | 0.729 | 1.183 | 0.549 | 0.946 | 0.741 | 1.206 | 0.652 | 0.919 | 0.717 | 1.179 | 0.508 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Early morning awakening(EMA) | Yes | 0.423 | 0.360 | 0.497 | <0.001 | 0.766 | 0.599 | 0.980 | 0.034 | 0.807 | 0.629 | 1.036 | 0.092 | 0.870 | 0.673 | 1.123 | 0.285 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Sleep enhancing medication use (SEMU) | Yes | 0.464 | 0.381 | 0.565 | <0.001 | 0.744 | 0.554 | 1.000 | 0.049 | 0.752 | 0.558 | 1.014 | 0.062 | 0.851 | 0.625 | 1.159 | 0.306 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Excessive daytime sleepiness(EDS) | Yes | 0.543 | 0.464 | 0.634 | <0.001 | 0.689 | 0.552 | 0.861 | 0.001 | 0.724 | 0.578 | 0.907 | 0.005 | 0.783 | 0.621 | 0.981 | 0.038 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Restless legs syndrome(RLS) | Yes | 0.726 | 0.662 | 0.796 | <0.001 | 0.583 | 0.419 | 0.812 | 0.001 | 0.573 | 0.410 | 0.802 | 0.001 | 0.678 | 0.480 | 0.957 | 0.027 |
| | No | 1.000 | | | | 1.000 | | | | 1.000 | | | | 1.000 | | | |
| Subjective sleep sufficiency | Sufficient | 1.000 | | | | | | | | 1.000 | | | | 1.000 | | | |
| | Insufficient | 0.244 | 0.176 | 0.340 | <0.001 | | | | | 0.399 | 0.269 | 0.592 | <0.001 | 0.472 | 0.315 | 0.707 | <0.001 |
| Self-rated health | Good | 1.000 | | | | | | | | | | | | 1.000 | | | |
| | Fair | 0.484 | 0.382 | 0.612 | <0.001 | | | | | | | | | 0.604 | 0.467 | 0.780 | <0.001 |
| | Poor | 0.141 | 0.107 | 0.185 | <0.001 | | | | | | | | | 0.253 | 0.185 | 0.346 | <0.001 |

$: Univariate and multivariate logistic regression analysis, Response variable: PGC Morale Scale score ≥9.
#1: Model 1 includes all variables except self-rated health and subjective sleep sufficiency.
#2: Model 2 includes all variables except self-rated health.
#3: Model 3 includes all variables for adjustment.
‡: CI, Confidence interval.
§: Reference.

in all models. No significant association was recognized in the adjusted odds ratios for DMS in Model 1. Significant associations disappeared in adjusted odds ratios for EMA and SEMU in Model 2.

When the crude odds ratio for a sleep duration of 7–8 h was used as the reference, the crude odds ratios for sleep durations of <6 and ⩾9 h were significantly lower. An inverted U-shaped association was observed, as shown in Fig. 2. Similarly, in Model 1, the adjusted odds ratio showed an inverted U-shaped association, and the adjusted odds ratio for a sleep duration of ⩾9 h was significantly lower. However, in Model 2, an inverted U-shaped association of the adjusted odds ratio was not recognized, and in particular, there was no tendency for the odds ratio to be lower for a sleep duration of <6 h. In Model 3, there was no tendency for the adjusted odds ratios to be lower for sleep durations of <6 and ⩾9 h. Therefore, various models were created using different combinations of covariates (Tables 3 and 4). Based on this table, we concluded that the covariates influencing the lowering trend of the odds ratio for a sleep duration of <6 h were (1) existence of DIS, (2) psychological stress combined with sleep disorders, (3) poor subjective sleep sufficiency, and (4) an association with the level of self-rated health. The level of self-rated health was suggested to be a factor that influenced the lowering trend of the odds ratio for a sleep duration of ⩾9 h.

## 4. Discussion

This is the first report to have examined the associations between PGC scores and sleep.

"The level of happy aging" is generally termed as "subjective well-being." Up to now, the most widely used measure for evaluating this condition has been the PGC Morale Scale developed by Lawton [9]. Studies of the Japanese version have also yielded sufficient validity and reliability. This scale is intended to evaluate morale in terms of three constituent factors subdivided into 11 items: agitation (4 items); attitude toward own aging (3 items); and lonely dissatisfaction (4 items). The total score thus obtained represents the examinee's subjective well-being. According to a comparative study of the 11-item PGC Morale Scale conducted in Japan and the United States [11], factor analysis demonstrated that the factorial structure did not differ significantly. In the present investigation, therefore, we used the 11-item PGC Morale Scale to study subjective well-being.

Table 4
Adjusted odds ratios for PGC Morale Scale scores according to sleep duration using various combinations of covariates and changes in their statistical significances ¶

| Combination of covariates# | Sleep duration (hour) | | | | |
|---|---|---|---|---|---|
| | <6 | 6–7 | 7–8 | 8–9 | 9⩽ |
| Base | 0.603* | 0.819 | 1† | 1.012 | 0.669* |
| Base + DIS | 0.730 | 0.921 | 1 | 0.636 | 0.387* |
| Base + DMS | 0.635* | 0.836 | 1 | 1.012 | 0.692* |
| Base + EMA | 0.669* | 0.853 | 1 | 0.974 | 0.651* |
| Base + SEMU | 0.671* | 0.829 | 1 | 1.020 | 0.694* |
| Base + EDS | 0.629* | 0.818 | 1 | 0.996 | 0.689* |
| Base + RLS | 0.622* | 0.821 | 1 | 1.032 | 0.712* |
| Base + Stress | 0.672* | 0.883 | 1 | 1.004 | 0.684* |
| Base + Stress + DIS | 0.781 | 0.956 | 1 | 0.959 | 0.672* |
| Base + Stress + DMS | 0.704 | 0.894 | 1 | 1.010 | 0.729* |
| Base + Stress + EMA | 0.730 | 0.901 | 1 | 0.985 | 0.693* |
| Base + Stress + SEMU | 0.731 | 0.885 | 1 | 1.000 | 0.726* |
| Base + Stress + EDS | 0.702 | 0.883 | 1 | 0.999 | 0.721* |
| Base + Stress + RLS | 0.689 | 0.874 | 1 | 1.022 | 0.739 |
| Base + Pain | 0.647* | 0.828 | 1 | 0.972 | 0.677* |
| Base + Pain + DIS | 0.758 | 0.925 | 1 | 0.931 | 0.628* |
| Base + Pain + DMS | 0.673* | 0.849 | 1 | 0.973 | 0.678* |
| Base + Pain + EMA | 0.704 | 0.861 | 1 | 0.939 | 0.639* |
| Base + Pain + SEMU | 0.706 | 0.842 | 1 | 0.981 | 0.679* |
| Base + Pain + EDS | 0.668* | 0.832 | 1 | 0.958 | 0.675* |
| Base + Pain + RLS | 0.661* | 0.836 | 1 | 0.994 | 0.696* |
| Base + Sufficiency | 0.839 | 0.907 | 1 | 0.988 | 0.653* |
| Base + Sufficiency + Stress | 0.897 | 0.945 | 1 | 1.000 | 0.715* |
| Base + Health | 0.710 | 0.841 | 1 | 1.025 | 0.795 |
| Base + Health + Sufficiency | 1.054 | 1.017 | 1 | 0.952 | 0.761 |

#: Covariates: Base: [Age + Gender + Place of residence + Educational history], Stress: Psychological stress, Pain: Physical pain, Sufficiency: Subjective sleep sufficiency Health: Self-rated health.
¶: Multivariate logistic regression analysis, Response variable: PGC Morale Scale score⩾9.
*: $p \leqq 0.05$.
†:Sleep duration: 7–8 h as a reference.

With regard to the association between subjective sleep sufficiency and PGC score, the mean score values increased with increasing subjective sleep sufficiency. There was a positive linear association between subjective well-being and subjective sleep sufficiency. Moreover, a similar association was observed with regard to the adjusted odds ratios in Model 3. Thus, it was indicated that an improvement in subjective sleep sufficiency, a qualitative parameter, must be considered to improve subjective well-being.

With regard to sleep disorders, since subjective well-being was significantly associated with DIS, EDS, and RLS in the logistic regression model, it was suggested that these sleep disorders had an independent and strong association with deterioration in subjective well-being. Conventionally, it is believed that DMS and EMA are common among the elderly [1,2]. The fact that DMS and EMA were not associated with subjective well-being may be because both are extremely common symptoms among the elderly and are not particularly recognized as irritants.

Among the sleep disorders included in this study, DIS was the strongest factor associated with deterioration in subjective well-being. A previous study has reported a significant association between DIS and depression, but not between DMS/EMA and depression, among the Japanese elderly [6]. Thus, depression among the Japanese elderly may affect their subjective well-being. Another study supports this inference of an association between depression and subjective well-being [7]. A similar trend may apply to sleep disorders that are associated with depression and subjective well-being.

In Model 2, after the odds ratios had been adjusted for subjective sleep sufficiency, no significant associations were observed between the EMA/SEMU and PGC scores. This suggests that if subjective sleep is sufficient, EMA and SEMU may not be associated with deterioration in subjective well-being.

The strong association of EDS with deterioration in subjective well-being may be due to the fact that (1) EDS is a symptom that may be caused by various sleep disorders, (2) it is strongly associated with depression, and (3) a previous study has reported that EDS is also associated with RLS [2].

A strong significant association was observed between RLS [17] and subjective well-being, and a previous study has reported an association between depression and RLS [7] among Japanese elderly men. Here, too, a depressive state may be involved.

The present study is the first to indicate that there are strong associations between subjective well-being and DIS/EDS/RLS, and that the associations of subjective well-being with DMS, EMA, and SEMU could be modified by using variables for adjustment.

With regard to sleep duration, previous studies that examined associations between subjective indices (such as mortality) and sleep duration obtained dissimilar results. Many studies have reported that health level was maximal for a sleep duration of 7–8 h and became lower for sleep durations that were shorter or longer (U-shaped association) [18,19]. However, some studies have reported gender-specific differences in whether or not a U-shaped association was observed [20,21]. Some other studies have reported no U-shaped association [22]. With regard to associations between objective indices using the Center for Epidemiologic Studies Depression Scale (CES-D) scores and sleep duration, a U-shaped association has been reported, the scores being lowest for a sleep duration of 6–8 h [5]. Therefore, in the present study, analyses were performed to clarify if there was an inverted U-shaped association between subjective well-being and sleep duration and, if present, to identify the mechanism that contributed to this association.

With regard to the association between subjective well-being and sleep duration, the mean values of the PGC scores (measurement of subjective well-being) showed an inverted U-shaped association, with the peak occurring at a sleep duration of 7–8 h. Based on this, it is inferred that for better subjective well-being, it is important to ensure appropriate sleep duration. However, the adjusted odds ratios for sleep duration in Model 2, in which psychological stress and subjective sleep sufficiency were added as variables for adjustment, did not show an inverted U-shaped association. However, significant lowering of the odds ratio at a sleep duration of $\geqslant$9 h was observed. This suggests that for better subjective well-being, mitigation of psychological stress and a higher level of sleep sufficiency are important, regardless of sleep duration. It also suggests that subjective well-being of those whose sleep duration was <6 h is not deteriorated if measures are taken to alleviate both psychological stress and sleep disorders and if the subjective sleep sufficiency is high. It also suggests that the subjective well-being of those whose sleep durations are <6 or $\geqslant$9 h can be modified by self-rated health, a known strong predictor of prognosis [16]. Furthermore, deterioration in health is always associated with a deterioration in QOL, regardless of sleep duration.

Briefly, as shown in this study, it is suggested that a universal association (U-shaped or inverted U-shaped association) exists between subjective well-being and sleep duration, which is similar to the association observed between mortality and sleep duration, and that it can be modified by various factors. It is also suggested that different factors are involved in the modification of subjective well-being for sleep durations of <6 and $\geqslant$9 h. In order to improve subjective well-being, it is necessary to elucidate its associations with these factors. Further studies with this objective are expected.

This is the first study to report the existence of an inverted U-shaped association between subjective well-being and sleep duration when analysis was performed without adjusting for covariates. It also demonstrated a linear association after adjusting for covariates.

Among the various factors associated with the PGC Morale Scale scores used in this study, psychological stress and physical pain contributed to the deterioration in subjective well-being (lower adjusted odds ratios). As it was inferred that these two factors were associated, in particular, with deterioration of subjective well-being among the elderly, they were included as variables for adjustment. Many studies have examined associations between sleep and psychological stress and physical pain [1,23]. It was suggested that although the influence of physical pain was not as strong as that of psychological stress, if the subject suffered from EMA and SEMU, physical pain influenced the deterioration in subjective well-being of those whose sleep duration was <6 h. A previous study has reported an association between depression and sleep disturbance caused by pain [6]. This may be related to the above-mentioned association between physical pain and subjective well-being.

This study had some limitations. First, since it was a cross-sectional study, a causal relationship could not be established between subjective well-being and sleep. However, this study utilized the results of the third survey that was part of the longitudinal study, and a follow-up study is planned. Second, no objective methods (physiological methods such as polysomnography) were employed to investigate sleep disorders. However, in a large-scale random-sampling survey, it is almost impossible to employ a physiological method. We expect further developments in the establishment of objective methods, including physiological methods, which will improve the reliability of such studies.

Third, the response rate of participants who answered all items of the PGC Morale Scale was low. Hence, there may have been a non-responder bias.

We expect that the results of this study will contribute to improving the subjective well-being of the elderly and understanding the characteristics of sleep disorders, since it demonstrates the associations between subjective well-being and subjective sleep sufficiency and appropriate sleep duration.

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## References

[1] Kim K, Uchiyama M, Okawa M, Liu X, Ogihara R. An epidemiological study of insomnia among Japanese general population. Sleep 2000;23(1):41–7.
[2] Kaneita Y, Ohida T, Uchiyama M, et al. Excessive daytime sleepiness among Japanese general population. J Epidemiol 2005;15(1):1–8.
[3] Inami Y, Horiguchi J, Innami T, et al. An Epidemiological study of sleep-wake disorders in the elderly. Seishin Igaku 1990;32(5):521–6. in Japanese.
[4] Hamashima C. The quality of life in aged people. Jpn J Hyg 1994;49:533–42. in Japanese.
[5] Kaneita Y, Ohida T, Uchiyama M, et al. The relationship between depression and sleep disturbances: A Japanese nationwide general population survey. J Clin Psychiatr 2006;67(2):196–203.
[6] Sukegawa T, Itoga M, Seno H, et al. Sleep disturbance and depression in the elderly in Japan. Psychiatr Clin Neurosci 2003;57:265–70.
[7] Demura S, Sato S. Relationship between depression, lifestyle and quality of life in the community elderly: a comparison between gender and age groups. J Physiol Anthropol Appl Human Sci 2003;22(3):159–66.
[8] Saito Y. A Survey on Health and Lifestyle. report series No.1. The Nihon University Center for Information Networking 2000.
[9] Lawton MP. The Philadelphia Geriatric Center Morale Scale: a revision. J Gerontol 1975;30(1):85–9.
[10] Liang J, Bollen KA. The structure of The Philadelphia Geriatric Center Morale Scale: a reinterpretation. J Gerontol 1983;38(2):181–9.
[11] Liang J, Asano H, Bollen KA, Kahana EF, Maeda D. Cross-cultural comparability of the Philadelphia Geriatric Center Morale Scale: an American- Japanese comparison. J Gerontol 1987;42(1):37–43.
[12] Ohida T, Kamal AMM, Uchiyama M, et al. The influence of lifestyle and health status factors on sleep loss among Japanese general population. Sleep 2001;24(3):333–8.
[13] Ohida T, Osaki Y, Doi Y, et al. An epidemiological study of self-reported sleep disorders among Japanese adolescents. Sleep 2004;27(5):975–85.
[14] Liu X, Uchiyama M, Kim K, et al. Sleep loss and daytime sleepiness in general adult population of Japan. Psychiat Res 2000;93:1–11.
[15] Suzuki K, Ohida T, Sone T, et al. The prevalence of Restless legs syndrome among pregnant women in Japan and the relationship between restless legs syndrome and sleep disorders. Sleep 2003;26(6):673–7.
[16] Idler EL, Benyamini Y. Self-rated Health and Mortality: A Review of Twenty-Seven Community Studies. J Health Soc Behav 1997;38:21–37.
[17] Ekbom KA. Restless legs. Acta Med Scand 1945;158(Suppl):4–122.
[18] Wingard DL, Berkman LF. Mortality Risk Associated with Sleeping Patterns Among Adults. Sleep 1983;6(2):102–7.
[19] Kripke DF, Garfinkel L, Wingard DL, Klauber MR, Marler MR. Mortality associated with sleep duration and insomnia. Arch Gen Psychiatr 2002;59:131–6.
[20] Tamakoshi A, Ohno Y. Self-reported sleep duration as a predictor of all-cause mortality: results from the JACC study, Japan. Sleep 2004;27(1):51–4.
[21] Kojima M, Wakai K, Kawamura T, et al. Sleep pattern and total mortality: a 12-year follow-up study in Japan. J Epidemiol 2000;10:87–93.
[22] Kaplan GA, Seeman TA, Cohen RD, et al. Mortality among the elderly in the Alameda County Study: behavioral and demographic risk factors. Am J Public Health 1987;77:307–11.
[23] Roehrs T, Roth T. Sleep and Pain: Interaction of two vital functions. Semin Neurol 2005;25(1):106–16.

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Original Article

# Associations between sleep disturbance and mental health status: A longitudinal study of Japanese junior high school students

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ABSTRACT

*Background*: A limited number of longitudinal studies have addressed the association between sleep disturbance and mental health status among adolescents. To examine whether each of these is a risk factor for the onset of the other, we conducted a prospective longitudinal study of Japanese adolescents.

*Methods*: In 2004, we performed a baseline study of students attending three private junior high schools in Tokyo, and in 2006, a follow-up study was performed on the same population. The mean age of the subjects was 13 years. The Pittsburgh Sleep Quality Index was used to evaluate sleep disturbance, and the 12-item General Health Questionnaire was used to evaluate mental health status.

*Results*: The subjects were 698 students, of whom 516 were suitable for analysis. The incidence of newly developed poor mental health status during the 2 years leading to the follow-up study was 35.1%. New onset of poor mental health status was significantly associated with new onset of sleep disturbance and lasting sleep disturbance. The incidence of sleep disturbance during the 2 years leading to the follow-up study was 33.3%. New onset of sleep disturbance was significantly associated with new onset of poor mental health status and lasting poor mental health status.

*Conclusions*: Sleep disturbance and poor mental health status increase each other's onset risk.



## 1. Introduction

The sleep habits of adolescents tend to change easily because of the physical and social developments experienced by this age group. Among adolescents in developed countries, sleep disturbance is not a rare problem, and previous studies have reported that its prevalence ranges from 5% to 40% [1–8].

Mental health status is considered to be a major factor associated with adolescent sleep habits, and to date, many cross-sectional epidemiological studies have indicated a close association between the two [1–8]. In 1976, a study in the USA reported the association of subjective poor sleep with anxiety or depression among adolescents [1]. Similar findings were subsequently reported in New Zealand, Italy, China, and France [2–8]. Additionally, a Japanese study demonstrated that mental health status was associated with insomnia, sleep duration, and subjective sleep assessment among adolescents [9].

The academic significance of longitudinal studies is higher than that of cross-sectional studies because the former allows calculation of incidence as well as prevalence and the examination of causal relationships. Longitudinal studies of the association between sleep and mental health status among adolescents began to emerge around 2000, and data are still being accumulated. In a survey of adolescents in the USA over a 4-year period, Patten et al. found that depressive symptoms could be a risk for the onset of insomnia [10]. Roberts et al. reported that the presence of insomnia adversely affected the mental health status of adolescents aged 11–17 years over the course of one year [11]. The results of these two longitudinal studies suggest that the sleep and mental health statuses of adolescents have a bidirectional relationship in which either can be the cause or result of the other.

In the present study, we used epidemiological tools with verified validity and reliability to conduct a 2-year longitudinal survey of sleep and mental health status in adolescents. Our main purpose was to examine whether sleep disturbance and poor mental health status do, in fact, show a bidirectional relationship in which either can become a risk factor for the other's onset.

## 2. Methods

### 2.1. Subjects and data collection

The subjects of this study were 698 students who, in 2004, entered one of three private junior high schools in Tokyo that had adopted a unified 6-year lower and upper secondary school system. For participation in this study, we asked the heads of three schools located near our institute, and they extended their cooper-

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ation. Two surveys were conducted on the same population using self-administered questionnaires: (1) a baseline survey, and (2) a follow-up survey. The baseline survey was conducted in November 2004, and the follow-up survey was conducted in November 2006. The following method was employed in each survey: a homeroom teacher delivered (1) the instructions, (2) a self-administered questionnaire, and (3) an envelope to each student during class. The students were requested to complete the questionnaire on their own during a homeroom activity. After completing the questionnaire, each student put it in the envelope and sealed it. The sealed envelopes were collected and then opened for the first time at the investigating institution.

The following five common items were included in the questionnaires used in each survey. (1) Basic attributes: the participants were required to enter the school name, class name, their name, sex, and birth date. (2) Sleep status: the Japanese version of the Pittsburgh Sleep Quality Index (PSQI) was used to measure this [12,13]. The PSQI is a self-administered questionnaire developed for the evaluation of sleep quality and disturbances. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for these seven components yields one global score. The higher the score, the more sleep is considered to be disturbed. It has been reported that the sensitivity and specificity of the Japanese version of the PSQI are optimal when the cut-off point is set to six or higher [14]. In a previous study, we confirmed that valid results can be obtained when it is administered to Japanese junior high school students [15]. (3) Lifestyle: this item included questions on eating habits, club activities, commuting time, cram schools or after-school lessons, coffee- or tea-drinking habits, and the extent to which the subject played computer games. (4) Physical status: this included height and weight. (5) Mental health status: this item included questions on contentment in daily life and questions from the Japanese version of the 12-item General Health Questionnaire (GHQ-12) [16,17]. The GHQ-12 comprises 12 questions and the total score (0–12) is calculated by summing the scores (0–1) for each question. The higher the score, the poorer the mental health status is considered to be. Although the GHQ was created for surveys targeting adults, it is known that valid results can be obtained when it is administered to adolescents [18,19]. In the present study, the GHQ-12 cutoff point was set to four or higher, in accordance with previous studies [19–21].

The following instructions were provided to the students: (1) this survey is part of a medical study. What is written in the questionnaire will not be subject to evaluation related to participants' academic performance or punishment; (2) subjects' participation in the survey must be voluntary, and subjects who do not participate will not suffer any loss; (3) the completed questionnaires will not be seen by school teachers; (4) subjects' privacy will be strictly protected.

### 2.2. Ethical considerations

In this study, the following ethical considerations were taken into account: (1) subjects' participation in the study was voluntary, and their informed consent was required; (2) subjects' willingness to cooperate was confirmed in writing; and (3) permission to conduct the study was obtained from the Ethics Committee of the institution to which the authors belonged.

### 2.3. Definitions

In this study, students with GHQ-12 scores of four or higher were defined as having "poor mental health status," and those with GHQ-12 scores of less than four were defined as having "good mental health status." Additionally, students with PSQI scores of six or higher were defined as having "sleep disturbance."

### 2.4. Statistical analyses

First, mean sleep duration, mean bedtime, and mean wake-up time were calculated by gender for the baseline and follow-up surveys separately, and changes in sleep habits over the 2-year period were examined.

Second, logistic regression analyses were conducted to assess the association between poor mental health status and sleep disturbance in the baseline survey. In these analyses, gender and lifestyle and contentment with daily life at the time of the baseline were used as covariates.

Third, prevalence of poor mental health status and sleep disturbance at the time of the baseline and follow-up surveys was calculated. The percentage of students whose GHQ-12 scores at the baseline were less than four but increased to four or higher at the follow-up survey was also calculated as an incidence of poor mental health status. Similarly, the percentage of students whose PSQI scores at the baseline had been less than six but increased to six or higher at the follow-up survey was also calculated as an incidence of sleep disturbance.

Fourthly, logistic regression analysis was used to examine whether sleep disturbance could be a risk factor for new onset of poor mental health. For this analysis, only participants who did not display poor mental health status at the time of the baseline were selected. The response variable was being in poor mental health status at follow-up, and sleep disturbance, gender, and lifestyle and contentment with daily life at the time of the baseline were used as covariates.

Finally, logistic regression analysis was used to examine whether mental health status could be a risk factor of new onset of sleep disturbance. For this analysis, only participants who did not display sleep disturbance at the time of the baseline were selected. The response variable was the presence of sleep disturbance at follow-up, and mental health status, gender, and lifestyle and contentment with daily life at the time of the baseline were used as covariates. SPSS 12.0J for Windows was used for statistical analyses.

## 3. Results

At the time of the baseline survey, 685 of the 698 subjects agreed to participate in the survey. The number of participants had decreased to 681 by the time of the follow-up survey because they had moved away from the area. Of these 681 subjects, 634 agreed to participate in the follow-up survey. The number of students whose survey data at the baseline and follow-up could be linked with the names written in the questionnaires was 619. Of these, 103 were excluded because of incomplete answers to the GHQ-12 or PSQI. Data from the remaining 516 subjects were analyzed. The percentage of the analyzed subjects among all subjects who participated in the baseline survey was calculated to be 73.9%.

Characteristics of the analyzed subjects at the baseline are shown in Table 1. Boys accounted for 57%, outnumbering girls at 43%.

The mean sleep duration, mean bedtime, and mean wake-up time recorded at each survey are shown in Table 2. In both surveys, sleep duration for girls was significantly shorter than that for boys (at the baseline survey: $p < 0.01$, at the follow-up survey: $p = 0.02$). In both boys and girls, the mean sleep duration became shorter in the 2 years (in boys: $p < 0.01$, in girls: $p < 0.01$), and the reason for this was delay of bedtime.

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**Table 1**
Characteristics of the analyzed subjects at the time of the baseline survey (2004).

| | N | % |
|---|---|---|
| *Sex* | | |
| Boys | 294 | 57.0 |
| Girls | 222 | 43.0 |
| *Age* | | |
| 13 years old | 514 | 99.6 |
| 14 years old | 1 | 0.2 |
| 15 years old | 1 | 0.2 |
| *Eating breakfast every day* | | |
| Yes | 435 | 84.3 |
| No | 81 | 15.7 |
| *Drinking coffee every day* | | |
| No | 480 | 93.0 |
| Yes | 36 | 7.0 |
| *Drinking tea every day* | | |
| No | 442 | 85.7 |
| Yes | 72 | 14.0 |
| Unknown | 2 | 0.4 |
| *Activity of sport club* | | |
| No | 114 | 22.1 |
| Yes | 395 | 76.6 |
| Unknown | 7 | 1.4 |
| *Activity of cultural club* | | |
| No | 405 | 78.5 |
| Yes | 93 | 18.0 |
| Unknown | 18 | 3.5 |
| *Going to cram schools or after-school lessons* | | |
| No | 280 | 54.3 |
| Yes | 235 | 45.5 |
| Unknown | 1 | 0.2 |
| *Playing computer games* | | |
| No | 200 | 38.8 |
| Yes | 316 | 61.2 |
| *Commuting time* | | |
| Less than one hour | 339 | 65.7 |
| One hour or more | 173 | 33.5 |
| Unknown | 4 | 0.8 |
| *Satisfaction of daily life* | | |
| Good | 397 | 76.9 |
| Poor | 90 | 17.4 |
| Unknown | 29 | 5.6 |
| *BMI* | | |
| Less than 20 | 355 | 68.8 |
| 20 or more | 122 | 23.6 |
| Unknown | 39 | 7.6 |
| *Mental health status* | | |
| Good | 319 | 61.8 |
| Poor | 197 | 38.2 |
| *Sleep disturbance* | | |
| Without | 312 | 60.5 |
| With | 204 | 39.5 |

The factors associated with poor mental health status as recognized in the baseline survey were poor satisfaction of daily life (odds ratio: 5.67 [95%CI:3.12–10.31], $p < 0.01$) and sleep disturbance (odds ratio: 2.68 [95% CI: 1.69–4.24], $p < 0.01$). The factors associated with sleep disturbance were drinking tea every day (odds ratio: 2.00 [95% CI: 1.07–3.75], $p = 0.03$), poor satisfaction of daily life (odds ratio: 2.63 [95% CI: 1.45–4.76], $p = 0.01$), and poor mental health status (odds ratio: 2.67 [95% CI: 1.69–4.23], $p < 0.01$).

**Table 3**
Changes in mental health status over 2 years.

| Mental health status from 2004 to 2006 | Boys | Girls | Overall |
|---|---|---|---|
| From "good" to "good" | 131(44.6) | 76(34.2) | 207(40.1) |
| From "poor" to "good" | 49(16.7) | 31(14.0) | 80(15.5) |
| From "good" to "poor" | 62(21.1) | 50(22.5) | 112(21.7) |
| From "poor" to "poor" | 52(17.7) | 65(29.3) | 117(22.7) |
| Total | 294(100.0) | 222(100.0) | 516(100.0) |

Data are presented as number (%).

Changes in mental health status over the 2 years are shown in Table 3. Prevalence of poor mental health status increased from 38.2% at the baseline to 44.4% at follow-up. Among the participants who did not exhibit poor mental health in the baseline survey, the incidence of newly developed poor mental health status during the 2 years leading to the follow-up study was 35.1%.

Changes in sleep disturbance in the 2 years are shown in Table 4. The prevalence of sleep disturbance increased from 39.5% at the baseline to 48.1% at the follow-up. Among the participants who did not exhibit sleep disturbance in the baseline survey, the incidence of sleep disturbance during the 2 years leading to the follow-up study was 33.3%.

The results of the analysis with regard to risk of new onset of poor mental health status are shown in Table 5. It was indicated that new onset of sleep disturbance or continuously suffering from sleep disturbance during the 2 years could be a risk for new onset of poor mental health status. Among the students who recovered from sleep disturbance in the 2 years, multivariate analysis did not show a significantly higher risk of new onset of poor mental health status.

The results of the analysis with regard to the risk of new onset of sleep disturbance are shown in Table 6. It was indicated that worsening of mental health status or remaining in poor health during the 2 years could be risk factors for new onset of sleep disturbance. Among the students who recovered from poor to good mental health status in the 2 years, the analysis did not demonstrate a significantly higher risk of new onset of sleep disturbance.

## 4. Discussion

The characteristic points of this study were as follows: (1) we designed a longitudinal and prospective study that enabled us to examine the causal relationship between sleep disturbance and mental health status, and (2) we used questionnaires containing questions from the PSQI and GHQ-12, which are widely employed internationally, to evaluate sleep disturbance and mental health status in order to ensure the validity of our evaluation. To our knowledge, no study of adolescents similar to this one has been reported to date.

The association between sleep disturbance (such as insomnia) and mental health status (such as depression) has long attracted interest, and exhaustive epidemiological studies targeting adults have been conducted [22–25]. Chang et al. surveyed 1053 univer-

**Table 2**
Mean sleep duration, mean bedtime, and mean wake-up time at the baseline (2004) and follow-up (2006) surveys.

| Sex | Baseline survey in 2004 | | | Follow-up survey in 2006 | | |
|---|---|---|---|---|---|---|
| | Mean sleep duration | Mean bedtime | Mean wake-up time | Mean sleep duration | Mean bedtime | Mean wake-up time |
| Boys | 7 h and 11 min | 11:06 PM | 6:31 AM | 6 h and 42 min | 11:40 PM | 6:38 AM |
| Girls | 6 h and 48 min | 11:27 PM | 6:24 AM | 6 h and 28 min | 11:49 PM | 6:32 AM |

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**Table 4**
Changes in sleep disturbance over 2 years.

| Sleep disturbance from 2004 to 2006 | Boys | Girls | Overall |
|---|---|---|---|
| From "without" to "without" | 128(43.5) | 80(36.0) | 208(40.3) |
| From "with" to "without" | 26(8.8) | 34(15.3) | 60(11.6) |
| From "without" to "with" | 73(24.8) | 31(14.0) | 104(20.2) |
| From "with" to "with" | 67(22.8) | 77(34.7) | 144(27.9) |
| Total | 294(100.0) | 222(100.0) | 516(100.0) |

Data are presented as number (%).

sity graduates for an average of 34 years and reported that those who suffered from insomnia during their school days demonstrated a significantly higher risk of developing depression later in life [22]. Similar results have been reported in other longitudinal studies, although the length of the observation periods differed [23–25]. Therefore, it is widely recognized that sleep disturbance among adults can be a risk factor for poor mental health status.

To date, few epidemiological studies have examined the association between sleep disturbance and mental health status among adolescents. Because the studies conducted on adolescents in Japan and overseas since the late 1970s were cross-sectional, chronological changes in mental health status and sleep status could not be clarified, and data pertaining to the onset order of poor mental health and sleep disturbance were not collected from subjects who suffered from both [1–9]. Thus, although these cross-sectional studies revealed that mental health status and sleep status were significantly associated, their causal relationships were not examined. In 2006, Johnson et al. conducted a retrospective study of adolescents aged 13–16 years and found that preceding insomnia was associated with onset of depression, whereas preceding depression was not associated with onset of insomnia [26]. This type of retrospective study allows a causal relationship to be examined to a certain extent, although the issue of recall bias remains a problem. In order to resolve those problems recognized in previous studies, we designed a prospective longitudinal study. Our results revealed that in adolescents, sleep disturbance and poor mental health status have a bidirectional relationship in which either can be a cause or a result.

The bidirectional relationship between sleep disturbance and mental health status in adults has already been reported. In a prospective 1-year longitudinal study, Morphy et al. indicated that the

**Table 5**
Odds ratio regarding new onset of poor mental health status.

| | Crude OR | 95% CI | *P* value | Adjusted OR | 95% CI | *P* value |
|---|---|---|---|---|---|---|
| *Sleep disturbance from 2004 to 2006* | | | | | | |
| From "without" to "without" | 1.00 | Reference | | 1.00 | Reference | |
| From "with" to "without" | 2.79 | 1.30, 5.99 | 0.01 | 2.00 | 0.87, 4.61 | 0.10 |
| From "without" to "with" | 4.56 | 2.46, 8.45 | <0.01 | 4.45 | 2.26, 8.76 | <0.01 |
| From "with" to "with" | 4.76 | 2.44, 9.29 | <0.01 | 5.81 | 2.70, 12.51 | <0.01 |
| *Sex* | | | | | | |
| Boys | 1.00 | Reference | | 1.00 | Reference | |
| Girls | 1.39 | 0.87, 2.22 | 0.17 | 1.27 | 0.66, 2.47 | 0.47 |
| *Eating Breakfast every day* | | | | | | |
| Yes | 1.00 | Reference | | 1.00 | Reference | |
| No | 1.39 | 0.72, 2.68 | 0.32 | 0.99 | 0.45, 2.18 | 0.97 |
| *Drinking coffee every day* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.92 | 0.38, 2.22 | 0.85 | 0.76 | 0.26, 2.16 | 0.60 |
| *Drinking tea every day* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.29 | 0.64, 2.59 | 0.48 | 1.05 | 0.44, 2.51 | 0.90 |
| *Activity of sport club* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.82 | 0.48, 1.41 | 0.47 | 0.94 | 0.39, 2.32 | 0.90 |
| *Activity of cultural club* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.28 | 0.70, 2.33 | 0.42 | 1.23 | 0.46, 3.31 | 0.68 |
| *Going to cram schools or after-school lessons* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.72 | 0.46, 1.15 | 0.17 | 0.84 | 0.48, 1.48 | 0.55 |
| *Playing computer games* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.64 | 0.40, 1.02 | 0.06 | 0.63 | 0.33, 1.20 | 0.16 |
| *Commuting time* | | | | | | |
| Less than one hour | 1.00 | Reference | | 1.00 | Reference | |
| One hour or more | 0.84 | 0.51, 1.37 | 0.48 | 0.84 | 0.47, 1.51 | 0.57 |
| *Satisfaction of daily life* | | | | | | |
| Good | 1.00 | Reference | | 1.00 | Reference | |
| Poor | 1.66 | 0.72, 3.84 | 0.24 | 1.95 | 0.68, 5.54 | 0.21 |
| *BMI* | | | | | | |
| Less than 20 | 1.00 | Reference | | 1.00 | | |
| 20 or more | 1.08 | 0.62, 1.86 | 0.79 | 0.96 | 0.50, 1.83 | 0.90 |

Poor mental health was defined as a general health questionnaire (GHQ) score of ⩾4.
Logistic regression analysis was conducted on 319 subjects who did not display poor mental health status at the time of the baseline survey.
Response variable: Poor mental health status newly developed in the 2-year study period.
OR, odds ratio; CI, confidence interval.

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**Table 6**
Odds ratio regarding new onset of sleep disturbance.

| | Crude OR | 95% CI | P value | Adjusted OR | 95% CI | P value |
|---|---|---|---|---|---|---|
| *Mental health status from 2004 to 2006* | | | | | | |
| From "good" to "good" | 1.00 | Reference | | 1.00 | Reference | |
| From "poor" to "good" | 2.03 | 0.90, 4.60 | 0.09 | 2.13 | 0.75, 6.03 | 0.16 |
| From "good" to "poor" | 4.56 | 2.46, 8.45 | <0.01 | 4.63 | 2.32, 9.24 | <0.01 |
| From "poor" to "poor" | 7.30 | 3.55, 15.02 | <0.01 | 6.90 | 3.02, 15.76 | <0.01 |
| *Sex* | | | | | | |
| Boys | 1.00 | Reference | | 1.00 | Reference | |
| Girls | 0.68 | 0.41, 1.13 | 0.13 | 0.49 | 0.24, 0.99 | 0.05 |
| *Eating breakfast every day* | | | | | | |
| Yes | 1.00 | Reference | | 1.00 | Reference | |
| No | 0.95 | 0.44, 2.04 | 0.90 | 1.01 | 0.43, 2.38 | 0.98 |
| *Drinking coffee every day* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.47 | 0.63, 3.44 | 0.37 | 1.00 | 0.35, 2.82 | 0.99 |
| *Drinking tea every day* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.91 | 0.93, 3.92 | 0.08 | 1.63 | 0.65, 4.06 | 0.30 |
| *Activity of sport club* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.66 | 0.38, 1.15 | 0.14 | 0.64 | 0.27, 1.55 | 0.32 |
| *Activity of cultural club* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.24 | 0.66, 2.33 | 0.50 | 1.22 | 0.45, 3.31 | 0.70 |
| *Going to cram schools or after-school lessons* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 0.71 | 0.44, 1.15 | 0.16 | 0.86 | 0.48, 1.54 | 0.60 |
| *Playing computer games* | | | | | | |
| No | 1.00 | Reference | | 1.00 | Reference | |
| Yes | 1.27 | 0.77, 2.12 | 0.35 | 0.97 | 0.49, 1.93 | 0.93 |
| *Commuting time* | | | | | | |
| Less than one hour | 1.00 | Reference | | 1.00 | Reference | |
| One hour or more | 1.27 | 0.77, 2.08 | 0.35 | 1.09 | 0.60, 1.99 | 0.77 |
| *Satisfaction of daily life* | | | | | | |
| Good | 1.00 | Reference | | 1.00 | Reference | |
| Poor | 1.80 | 0.88, 3.68 | 0.10 | 1.05 | 0.42, 2.66 | 0.91 |
| *BMI* | | | | | | |
| Less than 20 | 1.00 | Reference | | 1.00 | Reference | |
| 20 or more | 1.00 | 0.56, 1.78 | 0.99 | 0.88 | 0.44, 1.77 | 0.72 |

Sleep disturbance was defined as a Pittsburgh Sleep Quality Index (PSQI) of ⩾6.
Logistic regression analysis was conducted on 312 subjects who stated that they did not suffer from sleep disturbance at the time of the baseline survey.
Response variable: Sleep disturbance newly developed in the 2-year study period.
OR, odds ratio; CI, confidence interval.

incidence of insomnia was significantly associated with anxiety and depression observed at the time of the baseline survey, and that onset of anxiety or depression was significantly associated with insomnia observed at the time of the baseline survey [27]. Thus, they reported that sleep disturbance and mental health status show a bidirectional relationship in which either can be a cause or a result of the other [27]. In previous studies conducted on adolescents, unidirectional relationships between sleep disturbance and poor mental health status were examined; these studies indicated that sleep disturbance was associated with onset of poor mental health status or that poor mental health status was associated with onset of sleep disturbance. However, no study to date has indicated a bidirectional relationship between these indicators in the same study population. Therefore, our findings provide new insight into the relationship between sleep and mental health in adolescents.

The following three inferences can be proposed in relation to the mechanism by which sleep disturbance and mental health status each act as risk factors for the other: (1) sleep disturbance and poor mental health status are associated via common factors. For example, certain genetic predispositions, familial factors, social factors, or environmental factors may play a role in the onset of both sleep disturbance and poor mental health status. (2) Sleep disturbance and poor mental health status are broadly included in the same category of disorders. In such cases, only the order of appearance of sleep symptoms and mental health symptoms may change. Ohayon and Roth reported that in the clinical course of mood disturbance and anxiety, insomnia symptoms could develop either earlier or later than mental health symptoms [28]. Their results support this second proposed mechanism. (3) Sleep disturbance and poor mental health status both belong to different categories of disorders, but each influences the onset of the other. Chang et al. indicated that among subjects who suffered from insomnia in their school days, the number of those who developed depression increased after the 18th year of follow-up [22]. Considering the extended period from the time insomnia was recognized to the onset of depression, it may be more useful to conclude that chronic insomnia played a facilitative role in the development of depression, a new pathological condition, rather than including insomnia and depression in the same pathological condition. It is difficult to determine which of the above three mechanisms has the best concordance with the association between sleep disturbance and poor mental health status. It may be better to consider that these three mechanisms are not mutually exclusive, but that they coexist.

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In this study, we used the term "risk factors" for the factors observed at the time of the baseline survey that were significantly associated with the pathological conditions developing during the 2-year observation period. However, a more accurate term might have been "precursors" or "prodromes" of each pathological condition. Eaton et al. termed personal characteristics and environmental factors associated with future development of pathological conditions "risk factors" because of their possible contribution to prevention of full-fledged development of disease [29]. They also termed the symptoms that should be included in the diagnostic criteria and that were manifested in the early stage of disease "precursors", and the symptoms that were recognized in the early disease stage and viewed retrospectively after the disease had met the diagnostic criteria, "prodromes" [29]. However, the significance of distinguishing these three terms is not very important for mental health activities and psychiatric treatment. In effect, among previous studies that examined associations between sleep and mental health status in adults, few clearly distinguished the three terms. Although the nuances of these three terms are different, their significance with regard to disease prevention is common. Whatever the symptoms, it may be possible to prevent development or exacerbation of other associated pathological conditions by taking measures against risk factors, precursors, or prodromes in order to eliminate them. In our multivariate analysis, subjects who suffered from sleep disturbance at the time of the baseline survey but had recovered from it at follow-up did not display a significantly high adjusted odds ratio with regard to onset of poor mental health status. Similarly, subjects who manifested poor mental health at the time of the baseline survey but had recovered from it at follow-up did not display a significantly high adjusted odds ratio with regard to onset of sleep disturbance. From these results, it can be inferred that treatment for sleep disturbance can be a preventive measure against the onset of poor mental health status, and that treatment of poor mental health status can be a preventive measure against the onset of sleep disturbance. It is important that any measures taken are based on a full understanding of the association between sleep and mental health status.

In this study, the adjusted odds ratio with regard to new onset sleep disturbance was significantly higher for boys than for girls. Many previous studies on sleep problems in adolescents have reported that the adjusted odds ratio with regard to sleep disturbance is significantly higher for girls than for boys [5,10,30]. The result of this study did not agree with those of the abovementioned studies. However, the prevalence of sleep disturbance among girls and boys at the time of the baseline survey were 50.0% and 31.6%, respectively (data not shown). This implies that many girls had developed sleep disturbance before the baseline survey was conducted. Therefore, the association of sleep disturbance with sex could vary according to the age of the subjects.

Some limitations affected this study. First, the three schools sampled in the study were private junior high schools located in Tokyo, and this resulted in a selection bias. It is inferred that social factors, such as whether the percentage of students intending to pursue university education is high in the enrolled school, the environment of the surrounding areas, and family financial conditions, may affect the sleep or mental health status of junior high school students. The study subjects did not represent the general population of Japanese junior high school students with regard to those social factors. To improve subject representation in future studies, survey subjects must be selected from multiple districts and from both public and private junior high schools. Second, not all issues associated with sleep or mental health status were covered in this study. For example, due to space limitations in the questionnaire, questions regarding alcohol drinking, smoking habits, snoring and obstructive sleep apnea were not included. These issues may affect sleep and mental health status. In our future studies, data that were not included in this study's questionnaire must be included to provide a broader overview of sleep and mental health status. Third, the self-evaluation tools such as the PSQI and GHQ were used for evaluating the sleep disturbance and mental health status of the subjects. However, these methods can yield biased information. It must be noted that some subjects may not be aware of their problem of sleep disturbance or poor mental health, and in such cases, their problems could not be evaluated by PSQI and GHQ.

In conclusion, we have examined associations between sleep disturbance and mental health status by conducting a 2-year longitudinal study of Japanese junior high school students. The results indicated that sleep disturbance could be a risk factor for new onset of poor mental health status and that poor mental health status could be a risk factor for new onset of sleep disturbance. It was suggested that sleep disturbance and mental health status show a bidirectional relationship, in which either can be a cause or result of the other. In order to promote mental health in adolescents, it will be important to fully understand the association between sleep disturbance and mental health status which has been clarified in the present study.

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## References

[1] Marks PA, Monroe LJ. Correlates of adolescent poor sleepers. J Abnorm Psychol 1976;85:243–6.
[2] Price VA, Coates TJ, Thoresen CE, Grinstead OA. Prevalence and correlates of poor sleep among adolescents. Am J Dis Child 1978;132:583–6.
[3] Morrison DN, McGee R, Stanton WR. Sleep problems in adolescence. J Am Acad Child Adolesc Psychiatry 1992;31:94–9.
[4] Gau SF, Soong WT. Sleep problems of junior high school students in Taipei. Sleep 1995;18:667–73.
[5] Manni R, Ratti MT, Marchioni E, et al. Poor sleep in adolescents: a study of 869 17-year-old Italian secondary school students. J Sleep Res 1997;6:44–9.
[6] Liu X, Uchiyama M, Okawa M, Kurita H. Prevalence and correlates of self-reported sleep problems among Chinese adolescents. Sleep 2000;23:27–34.
[7] Liu X, Zhou H. Sleep duration, insomnia and behavioral problems among Chinese adolescents. Psychiatry Res 2002;111:75–85.
[8] Bailly D, Bailly-Lambin I, Querleu D, Beuscart R, Collinet C. Sleep in adolescents and its disorders. A survey in schools [in French]. Encephale 2004;30:352–9.
[9] Kaneita Y, Ohida T, Osaki Y, et al. Association between mental health status and sleep status among adolescents: a nationwide cross sectional survey. J Clin Psychiatry 2007;68:1426–35.
[10] Patten CA, Choi WS, Gillin JC, Pierce JP. Depressive symptoms and cigarette smoking predict development and persistence of sleep problems in US adolescents. Pediatrics 2000;106:E23.
[11] Roberts RE, Roberts CR, Chen IG. Impact of insomnia on future functioning of adolescents. J Psychosom Res 2002;53:561–9.
[12] Buysse DJ, Reynolds 3rd CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res 1989;28:193–213.
[13] Doi Y, Minowa M, Uchiyama M, Okawa M. Development of the Japanese version of the Pittsburgh Sleep Quality Index (in Japanese). Jpn J Psychiatry Treat 1998;13:755–63.
[14] Doi Y, Minowa M, Uchiyama M, et al. Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh Sleep Quality Index (PSQI-J) in psychiatric disordered and control subjects. Psychiatry Res 2000;97:165–72.
[15] Asai T, Kaneita Y, Ohida T. Relationship of sleeping problems and mental health among junior high school students [in Japanese]. Adolescentology 2006;24:465–72.
[16] Goldberg DP, Rickels K, Downing R, Hesbacher P. A comparison of two psychiatric screening tests. Br J Psychiatry 1976;129:61–7.

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[17] Doi Y, Minowa M. Factor structure of the 12-item General Health Questionnaire in the Japanese general adult population. Psychiatry Clin Neurosci 2003;57:379–83.
[18] D'Arcy C, Siddique CM. Psychological distress among Canadian adolescents. Psychol Med 1984;14:615–28.
[19] Arakida M, Takahashi S, Aoyagi M, Kanamori M. Examination of mental health status and related factors in junior high school students: A three-year longitudinal investigation [in Japanese]. Shouni Hoken Kenkyuu 2003;62:667–79.
[20] Fuchino Y, Mizoue T, Tokui N, Ide R, Fujino Y, Yoshimura T. Health-related lifestyle and mental health among inhabitants of a city in Japan [in Japanese]. Nippon Koshu Eisei Zasshi 2003;50:303–13.
[21] Shimbo M, Nakamura K, Jing Shi H, et al. Green tea consumption in everyday life and mental health. Public Health Nutr 2005;8:1300–6.
[22] Chang PP, Ford DE, Mead LA, Cooper-Patrick L, Klag MJ. Insomnia in young men and subsequent depression. The Johns Hopkins Precursors Study. Am J Epidemiol 1997;146:105–14.
[23] Ford DE, Kamerow DB. Epidemiological study of sleep disturbances and psychiatric disorders. JAMA 1989;262:1479–84.
[24] Breslau N, Roth T, Rosenthal L, Andreski P. Sleep disturbance and psychiatric disorders: a longitudinal epidemiological study of young adults. Biol Psychiatry 1996;39:411–8.
[25] Roberts RE, Shema SJ, Kaplan GA, Strawbridge WJ. Sleep complaints and depression in an aging cohort: a prospective perspective. Am J Psychiatry 2000;157:81–8.
[26] Johnson EO, Roth T, Breslau N. The association of insomnia with anxiety disorders and depression: exploration of the direction of risk. J Psychiatr Res 2006;40:700–8.
[27] Morphy H, Dunn KM, Lewis M, Boardman HF, Croft PR. Epidemiology of insomnia: a longitudinal study in a UK population. Sleep 2007;30:274–80.
[28] Ohayon MM, Roth T. Place of chronic insomnia in the course of depressive and anxiety disorders. J Psychiatr Res 2003;37:9–15.
[29] Eaton WW, Badawi M, Melton B. Prodromes and precursors: epidemiologic data for primary prevention of disorders with slow onset. Am J Psychiatry 1995;152:967–72.
[30] Ohida T, Osaki Y, Doi Y, et al. An epidemiologic study of self-reported sleep problems among Japanese adolescents. Sleep 2004;27:978–85.

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**ORIGINAL ARTICLE**

# Email-based epidemiological surveys on restless legs syndrome in Japan

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**Abstract**

The prevalence, clinical significance and awareness of restless legs syndrome (RLS) have not been well identified in Japan. We conducted an Internet-based survey on the general Japanese population. Using an Internet-linked questionnaire, we evaluated 8126 respondents, consisting of a cross-section of Japanese adults aged 20 to 59 years. The questionnaire items consisted of demographic variables, the National Institute of Health/International RLS Study Group (IRLSSG) consensus questionnaire, the IRLSSG rating scale (IRLS), the Pittsburgh sleep quality index (PSQI), and questions regarding diagnosis and treatment. Probable RLS was found in 326 participants (4.01%). The prevalence was significantly higher in women (4.9%) than in men (3.0%), but did not differ by age. Most of the probable participants had mild to moderate IRLS severity and their average PSQI score was significantly higher than in unaffected participants. No probable RLS participants had been diagnosed with RLS, and only 7.7% had sought medical assistance. The prevalence of probable RLS in Japan is higher than in previous reports in Asia and, despite its low severity, the disorder is also thought to contribute to sleep disturbances in affected individuals. RLS is not well recognized in Japan and so promoting RLS awareness is necessary.

**Key words:** Asia, International Restless Legs Syndrome Study Group severity scale of RLS, National Institute of Health/International RLS Study Group consensus questionnaire, Pittsburgh sleep quality index.

## INTRODUCTION

Restless legs syndrome (RLS) is a disorder characterized by unpleasant leg sensations and the irresistible urge to move the lower extremities, occurring mainly at night.[1] RLS may be diagnosed using the diagnostic criteria of International RLS Study Group (IRLSSG), which consists of the following four items: (i) an urge to move the legs, usually accompanied or caused by an uncomfortable sensation in the legs; (ii) the beginning or worsening of symptoms during periods of rest or inactivity; (iii) the partial or total relief of symptoms by movement; and (iv) worse symptoms in the evening or night than during the day, or occurring only in the evening or night.[2]

Epidemiological investigations in western countries have reported that the prevalence of RLS ranges from 5 to 15% of the general population.[3–5] However, Tan *et al.*[6] reported that the prevalence of RLS was only 0.6% among an Asian population over 55-years' old and Mizuno *et al.*[7] indicated that the rate was 1.06% among people over 65 years in Izumo City. These results raise the possibility that the prevalence of RLS in the general Asian population is much lower than in western

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countries. However, these studies have primarily focused on elderly people and, to date, no studies have been performed using consensus questionnaires of IRLSSG on large numbers of young and middle-aged Japanese adults, comparable with the data from western countries. In addition, practical information on the diagnosis and treatment of RLS in the general Japanese population has not been evaluated. Several studies have revealed that RLS is often underdiagnosed and that only a few patients receive the generally recommended drug treatment,[8] even in western countries, in which the disorder is better understood.[9–11] It is also widely accepted that most patients with RLS seen in a clinical setting have insomnia,[9,10,12] but the relationship between RLS and sleep disturbances in the general population has not been identified from epidemiological data.

In order to clarify these issues, a systematic epidemiological study using a large sample is necessary. Internet surveys have been accepted as a useful method for collecting data from a large sample; enabling researchers to acquire quick information at a low cost and with a high response rate.[13,14] Moreover, electronic surveys in medical research have been reported to have great validity and to provide early identification of health community trends.[14] In the present study we investigated the prevalence and severity profile of RLS, the relationship between RLS and sleep disturbances, and information on the diagnosis and treatment of RLS in a general Japanese population using an Internet survey on a large sample of adults aged 20 to 59 years.

## METHODS

The ethics committees of the Neuropsychiatric Research Institute approved this study. A cross-sectional Internet-linked survey was conducted in August 2004. A total of 16 000 participants, consisting of 4000 participants for each 10-year age span from 20 to 59 years, were recruited, using stratified random sampling, by district, gender and age from the list of a market research company that maintains a panel of over 100 000 persons for marketing and survey purposes. Each participant was sent an e-mail containing questions on demographic variables and the existence and severity of RLS, as well as questions from the Pittsburgh sleep quality index (PSQI),[15] including their evaluation of their sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications and daytime dysfunction. The existence of probable RLS was determined using the Japanese version of the questions for epidemiological studies of RLS recommended by the Restless Legs Syndrome Diagnosis and Epidemiology Workshop at the National Institute of Health (NIH), in collaboration with members of the IRLSSG.[2]

The NIH/IRLSSG consensus questionnaire surveyed the following four items: (i) the presence of unpleasant leg sensations and an urge to move the legs; (ii) whether these uncomfortable feelings occurred only or mainly at rest and whether they improved with movement, e.g., by moving the legs, rubbing the legs and walking around; (iii) whether these uncomfortable feelings were worse in the evening or at night rather than in the morning; and (iv) how often these uncomfortable feelings occurred. Participants experiencing the first three items (i, ii and iii) at least once a year were judged to have probable RLS. The severity of the disorder was also self-rated, using the IRLSSG rating scale (IRLS).[16]

The cross-sectional study evaluated 9440 respondents (59%). After excluding 1314 samples (8.2%) with incomplete answers, the results of 8126 respondents (50.8%) with valid answers were analyzed. First, we estimated the prevalence of probable RLS and its relationship to demographic variables. Next, we investigated the relationship between sleep disturbances manifested on the PSQI and the existence of RLS. We separated participants with probable RLS into severity subgroups according to IRLS scores. The subgroup with fewer than 10 IRLS points was categorized as having mild RLS, those with 11 to 20 as having moderate RLS, those with 21 to 30 as having severe RLS, and those more than 31 as having very severe RLS.[16] We also compared demographic variables and the frequency of appearance of RLS symptoms ascertained from item 4 on the NIH/IRLSSG consensus questionnaire for each severity subgroup. Moreover, it was determined whether participants with probable RLS had been diagnosed with RLS previously and what kind of treatment they had received.

A $\chi^2$ test was used to identify subgroup differences in categorical variables. The Mann–Whitney U test was used to assess statistical differences in continuous variables between probable RLS and RLS-negative subgroups, and between participants who had or had not sought medical assistance for RLS symptoms. Statistical significance was considered to exist at $P < 0.05$. These statistical analyses were made using the Statistical Package for the Social Sciences (SPSS, version. 11.5J, 2002; SPSS, Tokyo, Japan).

## RESULTS

The total of 8126 participants with valid answers consisted of 3765 men and 4361 women. Of these, 1777

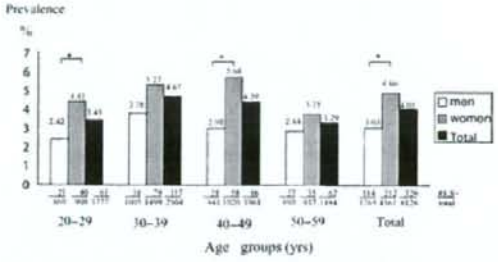


**Figure 1** Prevalence of participants with probable restless leg syndrome (RLS) by age subgroup and gender. $^*P < 0.05$, $\chi^2$ test. In each group the percentages are indicated over the columns. The number of participants with probable RLS/ total number is expressed below the columns. There was no statistical difference between the age subgroups; however, in 20–29-year old and 40–49-year old subgroups the rate was significantly higher in women than in men.

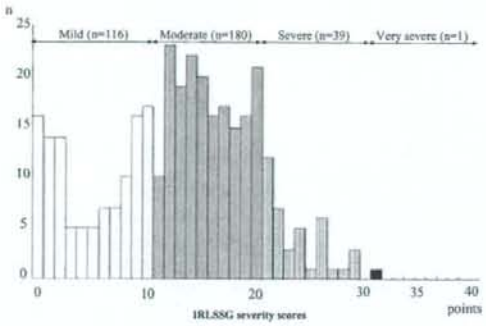


**Figure 2** Distribution of International Restless Leg Syndrome (RLS) Study Group rating scale scores among participants with probable RLS ($n = 326$). The longitudinal bar indicates the number of participants with each score (0 to 10 mild, 11 to 20 moderate, 21 to 30 severe, 31 to 40 very severe). , Mild = ■, moderate, ■, severe, ■, very severe.

participants (44%, 869 male, 908 female) ranged in age from 20 to 29 years; 2504 participants (63%, 1005 male, 1499 female) were 30 to 39-years old; 1961 participants (49%, 941 male, 1020 female) were 40 to 49-years old and 1884 participants (47%, 950 male, 934 female) were 50 to 59-years old.

A total of 326 participants (4.01%, 95% CI: 3.58–4.44) was judged as having probable RLS, according to the above criteria. The rate for probable RLS was significantly higher in women (4.86%, 95% CI: 4.23–5.49) than in men (3.03%, CI: 2.49–3.57) among the participants as a whole ($P < 0.01$). Moreover, as shown in Figure 1, the female predominance in the rate of participants with probable RLS was seen in both the 20–29 and 40–49 age subgroups, although the rate itself did not differ among the age subgroups.

The mean IRLS score among participants with probable RLS was 12.8 ± 7.9. Mild RLS was found in 116 (35.6%) participants, moderate RLS was found in 180 (55.1%) participants, severe RLS was found in 39 (12.0%) participantsand only one participant (0.3%) was judged to have very severe RLS (Fig. 2).

The total PSQI scores as well as the scores for most of the subcategories (sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance and daytime dysfunction) were significantly higher in the probable RLS subgroup than in the RLS-negative subgroup (Table 1). A small but significant positive correlation was also found between the total PSQI score and the IRLS score in participants with probable RLS ($r = 0.239$; $P = 0.001$).

Table 2 shows the demographic variables and the number of participants who sought medical assistance for RLS symptoms, as well as the subjective frequency of appearance of RLS symptoms. There were neither gender nor age differences among the severity subgroups; however, the rate of the number of the participants seeking medical assistance was significantly different between each severity group ($P = 0.014$). Although we could not identify the number of participants whose RLS symptoms occurred at least once a week, based on the NIH/IRLSSG consensus questionnaire, 131 participants (40.2%) revealed that they experienced RLS symptoms at least twice/week. The frequencies of the appearance of RLS symptoms were also significantly different between severity subgroups ($P = 0.001$).

Among the participants with probable RLS, only 25 (7.7%) reported consulting a physician for treatment of RLS symptoms. A comparison of the descriptive variables between participants who had sought medical assistance and those who did not show that the former group had significantly higher values for both age and IRLS score than the latter group. In addition, a larger percentage of participants who experienced RLS symptoms at least twice a week had consulted a physician. However, there was no difference in either the total PSQI score or the gender distribution between the two subgroups.

Of the 25 participants with probable RLS, 11 reported that they had consulted orthopedic surgeons, eight had

**Table 1** Comparison of Pittsburgh sleep quality index (PSQI) scores between groups with and without positive restless leg syndrome (RLS)

| | RLS-positive groups | RLS-negative groups | Significance |
|---|---|---|---|
| Sleep quality | 1.61 ± 0.65 | 1.27 ± 0.69 | * |
| Sleep latency | 1.37 ± 1.00 | 0.94 ± 0.91 | * |
| Sleep duration | 1.55 ± 0.89 | 1.42 ± 0.83 | ** |
| Habitual sleep efficiency | 0.35 ± 0.74 | 0.16 ± 0.49 | * |
| Sleep disturbance | 1.05 ± 0.43 | 0.88 ± 0.46 | * |
| Use of sleeping medications | 0.21 ± 0.67 | 0.18 ± 0.65 | NS |
| Daytime dysfunction | 1.22 ± 0.93 | 0.82 ± 0.84 | * |
| Sum scores of PSQI | 7.37 ± 3.16 | 5.68 ± 2.81 | * |

*$P = 0.001$, **$P = 0.003$. Values are expressed as mean ± SD. NS, not significant.

**Table 2** Demographic variables: the number of the participants who had sought medical assistance for the symptoms and frequencies of appearance of restless leg syndrome (RLS) symptom in each severity group

| | Mild ($n = 116$) | Moderate ($n = 170$) | Severe ($n = 39$) | Very severe ($n = 1$) | Significance |
|---|---|---|---|---|---|
| Age (years)† | 38.9 ± 9.2 | 39.3 ± 9.5 | 39.1 ± 9.0 | 43 | NS |
| Gender (M/F) | 38/78 | 68/102 | 8/31 | 0/1 | NS |
| The number of the participants who had sought medical assistance for the symptom (%) | 6 (5.1) | 11 (6.5) | 8 (20.5) | 0 | * |
| Frequency of the appearance of RLS symptom (%) | | | | | ** |
| Less than once a year | 0 | 0 | 0 | 0 | |
| Less than once a month | 51 (44.0) | 5 (2.9) | 1 (2.6) | 0 | |
| Once a month | 21 (18.1) | 16 (9.4) | 3 (7.7) | 0 | |
| 2–4 times a month | 32 (27.6) | 62 (36.5) | 4 (10.3) | 0 | |
| 2–3 times a week | 9 (7.7) | 49 (28.8) | 14 (35.9) | 0 | |
| 4–5 times a week | 3 (2.6) | 23 (13.5) | 10 (25.6) | 1 | |
| 6–7 times a week | 0 | 15 (8.8) | 7 (17.9) | 0 | |

*$P = 0.014$, **$P = 0.001$ †Values are expressed as mean ± SD. NS, not significant.

consulted general physicians, three had consulted gynecologists and one each had consulted a neurologist, neurosurgeon and dermatologist, respectively. However, none of them had consulted a sleep medicine specialist and none of the probable RLS participants reported that they had been diagnosed with RLS by the physicians whom they had consulted. With respect to treatment for RLS symptoms, non-steroidal anti-inflammatory drugs had been prescribed for two participants, minor tranquilizers for two participants and steroidal liniment for one participant. The remaining 20 participants had not received any kind of medication.

## DISCUSSION

This is the first report to reveal the prevalence of RLS in a large number of Japanese adults, comparable with those conducted in western countries, using the NIH/IRLSSG consensus questionnaire.[3–5] As a result of our analysis, we estimate the prevalence of RLS to be 4.01% among participants aged 20 to 59 years. However, we should consider the limitations of an email survey. First, the results of any email survey are likely to be affected by the interest of the participants, since they can answer questions freely under the strong protection of anonymity.[17]

The relatively high score of PSQI (5.68 ± 2.81) among the participants without RLS suggests that the participants in this survey suffered from some sleep problems and were interested in the content of this survey. Second, sampling bias should not be ignored, especially in elderly populations, since only highly educated persons of this generation are thought to participate in this kind of email survey. Moreover, those responding to questionnaires were predominated with women. The prevalence of RLS has been reported to be

higher in women than in men.[3,11,18-21] The distribution bias of the study participants might affect the result. Third, a face-to-face interview with a sleep disorder specialist is necessary to make a definitive diagnosis of RLS. For our subgroup of probable RLS participants, RLS remains merely probable, not definitive. However, considering that the response rate to our email survey exceeded 50% and that the rate of valid answers was sufficient for statistical analysis, this study could provide information about the prevalence of RLS in the general Japanese population.

Previously, Kageyama *et al.*[22] and Kim *et al.*[23] conducted large-sample questionnaire surveys on the prevalence of RLS in Asia and reported its prevalence in a Japanese and a Korean population of approximately 10% and 12.1%, respectively. Compared with these two studies, the 4.06% prevalence of probable RLS in our study seems quite low. However, our result is consistent with the report by Enomoto *et al.* showing that the prevalence of RLS was 3.0% in a large sample randomly selected throughout Japan.[24] Thus, we speculate that there is a possibility of overestimating the prevalence of RLS in the above two reports, perhaps owing to misunderstanding the meaning of questionnaire items.

The NIH/IRLSSG consensus questionnaires were previously used for an epidemiological study of an elderly German population, which reported a sensitivity of 87.5% and a specificity of 96% for detecting RLS.[25] These questionnaires were generated as a minimum core for a population-based epidemiological study based on three principles, as follows: (i) these would build upon a previously validated three-question set; (ii) the previously validated questionnaires would be modified to incorporate the newly established diagnostic criteria; and (iii) the framework for these would both provide universal verbal anchors and allow optical variable statements that could be completed with language-specific or dialect-specific descriptiors.[2] We believe that our study, which used these questionnaires, showed more accurate results than the two previous Asian studies that went beyond the sampling bias of an email survey. In future, we will perform a community-based epidemiological study with face-to-face interviews to estimate the true prevalence of RLS in Japan.

Judging from these results, the prevalence of RLS in Japan could be similar to that reported in a study in Turkey,[18] but higher than in previous reports, in which the prevalence of RLS in an Asian population was estimated to be extremely low.[6,7] Moreover, the well-known female predominance of RLS[7,11,19,20] and the increase in frequency of RLS symptoms with the severity of the disorder, as shown in the IRLS[11] were recognized in our results. In contrast, we did not see an age-dependent increase in the prevalence of RLS seen in reports on Caucasian populations.[11,12,21] Given the low prevalence of RLS in a rural elderly Japanese population[7] and the absence of an age-dependent increase in prevalence in the Turkish study,[18] it could be possible that RLS is not as prevalent among senior populations in Asia as it is in western countries. On the other hand, Enomoto *et al.*[24] and Kim *et al.*[23] reported an age-related increase in the prevalence of RLS despite the use in both studies of a single questionnaire. A future study focusing on the difference in prevalence between young and elderly Japanese populations is thus necessary.

In our study, the IRLS scores of participants with probable RLS were lower than those seen in a study conducted in the USA, in which the value was $23.8 \pm 6.8$,[13] and the rate of severely affected participants was lower than that reported in a French study.[11] This finding suggests again that the severity of RLS in the general adult Japanese population is lower than that of western countries. However, in the French study, the very severe IRLS group mainly consisted of elderly people.[11] Considering that our participants did not include elderly people 60 years old or more, an epidemiological RLS study on wider generations needs to be undertaken to obtain a conclusive information. In this study both the total PSQI score and the scores of most of its subscales were significantly higher in participants with probable RLS than in those with no evidence of RLS although the total PSQI score in unaffected participants were relatively high, as indicated above. However, elevation of PSQI scores significantly correlated with the severity of RLS in our study. These findings are similar to our previous reports of a Japanese population with Parkinson's disease[26] and end-stage renal disease.[27] In addition, the existence of probable RLS appeared as a significant independent variable associated with sleep disturbance. From these results we speculate that RLS in the general Japanese population contributes to the occurrence of sleep disturbance despite its low severity.

The number of participants who sought medical assistance for RLS symptoms was much lower in our study than in the French study.[11] This difference might be due to the low awareness of RLS in the general population in Japan. Moreover, the subgroup that did consult a physician showed higher IRLS severity scores, had more frequent appearances of RLS symptoms, and were older than the subgroup that had not consulted a physician. It is possible that their low symptom severity

and/or the relatively young age of the Japanese RLS participants might have contributed to the low rate of those seeking medical assistance.

The most striking finding of this study was that none of the probable RLS participants had been diagnosed with RLS and received a generally recommended treatment for the disorder.[8] This strongly suggests that there is a remarkably low awareness of the disorder among physicians in Japan. We speculate that the low awareness of RLS, both in the general population and among physicians, could play a role in the documented low prevalence of the disorder in this country, and that the rate would be higher after the sufficient promotion of a general awareness of the disorder.

In conclusion, the prevalence and severity of RLS in the general Japanese adult population is estimated to be lower than that in western countries. However, our results suggest that a large number of people who are affected by RLS symptoms as well as sleep disturbances secondary to the disorder may not yet have received proper diagnosis or treatment. Our results outline the necessity of further study on the prevalence of RLS through community-based surveys, and the need for promoting awareness of the disorder among both the general population and physicians.

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## REFERENCES

1 Ekbom KA. Restless legs syndrome. *Neurology* 1960; **10**: 863–73.
2 Allen RP, Picchietti D, Hening WA *et al.* Restless Legs Syndrome Diagnosis and Epidemiology Workshop at the National Institutes of Health; International Restless Legs Syndrome Study Group. Restless legs syndrome: diagnostic criteria, special considerations, and epidemiology. A report from the restless legs syndrome diagnosis and epidemiology workshop at the National Institutes of Health. *Sleep Med.* 2003; **4**: 101–19.
3 Rothdach AJ, Trenkwalder C, Haberstock J, Keil U, Berger K. Prevalence and risk factors of RLS in an elderly population: the MEMO Study. Memory and Morbidity in Augsburg Elderly. *Neurology* 2000; **54**: 1064–8.
4 Lavigne GJ, Montplaisir JY. Restless legs syndrome and sleep bruxism: prevalence and association among Canadians. *Sleep* 1994; **17**: 739–43.
5 Chokroverty S, Jankovic J. Restless legs syndrome: a disease in search of identity. *Neurology* 1999; **52**: 907–10.
6 Tan EK, Seah A, See SJ *et al.* Restless legs syndrome in an Asian population: a study in Singapore. *Mov. Disord.* 2001; **16**: 577–9.
7 Mizuno S, Miyaoka T, Inagaki T, Horguchi J. Prevalence of restless legs syndrome in non-institutionalized Japanese elderly. *Psychiatry Clin. Neurosci.* 2005; **59**: 461–5.
8 Littner MR, Kushida C, Anderson WM *et al.* Treatment resistant group. Practice parameters for the dopaminergic treatment of restless legs syndrome and periodic limb movement disorder. *Sleep* 2004; **27**: 557–9.
9 Hening W, Walters AS, Allen RP *et al.* Impact, diagnosis and treatment of restless legs syndrome (RLS) in a primary care population: the REST (RLS epidemiology, symptoms, and treatment) primary care study. *Sleep Med.* 2004; **5**: 237–46.
10 Allen RP, Walters AS, Montplaisir J *et al.* Restless legs syndrome prevalence and impact: REST general population study. *Arch. Intern. Med.* 2005; **165**: 1286–92.
11 Tison F, Crochard A, Leger D *et al.* Epidemiology of restless legs syndrome in French adults. A nationwide survey: The INSTANT Study. *Neurology* 2005; **65**: 239–46.
12 Rijsman R, Neven AK, Graffelman W *et al.* Epidemiology of restless legs in The Netherlands. *Eur. J. Neurol.* 2004; **11**: 607–11.
13 Allen RP, Kushida CA, Atkinson MJ, RLS QoL Consortium. Factor analysis of the International Restless Legs Syndrome Study Group's scale for restless legs severity. *Sleep Med.* 2003; **4**: 133–5.
14 Angelico F, Del Ben M, Francioso S *et al.* Attitudes and approach to cardiovascular risk factors in Italy: results of an electronic questionnaire survey. *Public Health* 2003; **117**: 242–9.
15 Doi Y, Minowa M, Uchiyama M *et al.* Psychometric assessment of subjective sleep quality using the Japanese version of the Pittsburgh sleep quality index (PSQI) in psychiatric disordered and control subjects. *Psychiatry Res.* 2000; **97**: 165–72.
16 The International Restless Legs Syndrome Study Group. Validation of the International Restless Legs Syndrome Study Group rating scale for restless leg syndrome. *Sleep Med.* 2003; **4**: 121–32.
17 Im EO, Chee W. Recruitment of research participants through the Internet. *Comput. Inform. Nurs.* 2004; **22**: 289–97.
18 Sevim S, Dogu O, Camdeviren H *et al.* Unexpectedly low prevalence and unusual characteristics of RLS in Mersin, Turkey. *Neurology* 2003; **61**: 1562–9.
19 Hogl B, Kiechl S, Willeit J *et al.* Restless legs syndrome: a community-based study of prevalence, severity, and risk factors. *Neurology* 2005; **64**: 1920–4.
20 Bjorvatn B, Leissner L, Ulfberg J *et al.* Prevalence, severity and risk factors of restless legs syndrome in the

general adult population in two Scandinavian countries. *Sleep Med.* 2005; **6**: 307–12.
21 Berger K, Luedemann J, Trenkwalder C *et al.* Sex and the risk of restless legs syndrome in the general population. *Arch. Intern. Med.* 2004; **164**: 196–202.
22 Kageyama T, Kabuto M, Nitta H *et al.* Prevalences of periodic limb movement-like and restless legs-like symptoms among Japanese adults. *Psychiatry Clin. Neurosci.* 2000; **54**: 296–8.
23 Kim J, Choi C, Shin K *et al.* Prevalence of restless legs syndrome and associated factors in the Korean adult population: the Korean Health and Genome Study. *Psychiatry Clin. Neurosci.* 2005; **59**: 350–3.
24 Enomoto M, Li L, Aritake S *et al.* Restless legs syndrome and its correlation with other sleep problems in the general adult population. *Sleep Biol. Rhythms* 2006; **4**: 153–9.
25 Nichols DA, Kushida C, Allen R *et al.* Validation of RLS diagnostic questions in a primary care practice [Abstract]. *Sleep* 2003; **26**: A346.
26 Nomura T, Inoue Y, Miyake M *et al.* Prevalence and clinical characteristics of restless legs syndrome in Japanese patients with Parkinson's disease. *Mov. Disord.* 2006; **21**: 380–4.
27 Kawauchi A, Inoue Y, Hachimoto T *et al.* Restless legs syndrome in hemodialysis patients: health-related quality of life and laboratory data analysis. *Clin. Nephrol.* 2006; **66**: 440–6.

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# Prevalence of Complex Sleep Apnea Among Japanese Patients with Sleep Apnea Syndrome

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Sleep apnea syndrome (SAS) is basically divided into two types: obstructive and central SAS. Recently, the concept of complex SAS has been advocated. Complex SAS is defined as SAS that initially manifests as primarily obstructive SAS, but is characterized by the frequent central apneas after the removal of upper airway obstruction. To determine the prevalence and clinical significance of complex SAS among Japanese patients with SAS, 1,312 patients with SAS were enrolled in this study. Diagnosis of central SAS was made based on diagnostic polysomnography, and differentiation of obstructive SAS from complex SAS was made from polysomnographic findings for treatment with continuous positive airway pressure, which resolved upper airway obstruction. As a result, obstructive SAS was found in 1,232 of 1,312 patients with SAS (93.9%) and central SAS was found in 14 patients (1.1%). The overall prevalence of complex SAS was 5.0% ($n = 66$). The prevalence of complex SAS among 1,218 male and 94 female patients with SAS were 5.3% and 1.1%, respectively. Patients with complex SAS had significantly higher apnea/hypopnea indices than patients with either obstructive or central SAS, but were similar in both mean age and average body mass index to obstructive SAS patients. There were no significant between-group differences in numbers of patients with clinical complications including hypertension, cardiac diseases, or cerebrovascular diseases. In conclusion, the prevalence of complex SAS in Japanese SAS patients is 5.0%, which is lower than previously reported prevalence of complex SAS in the USA and Australia. ——— obstructive sleep apnea syndrome; central sleep apnea syndrome; hypertension; cardiac disease; cerebrovascular disease.

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