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Original Article

The association between sleep disturbance and second-hand smoke exposure: a large-scale, nationwide, cross-sectional study of adolescents in Japan

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ABSTRACT

Objective: This study investigated the association between secondhand-smoke (SHS) exposure and sleep disturbance symptoms.
Methods: This study was a cross-sectional survey of junior and senior high school students throughout Japan. A total of 85,931 adolescents responded, and 84,988 questionnaires were included in the analysis.
Results: Adolescents who had never smoked accounted for 88.0% of respondents; among that group 39.1% reported having been exposed to SHS over the previous week. The results of multiple logistic regression analyses indicated that the adjusted odds ratios for insomnia symptoms such as difficulty initiating sleep (DIS), difficulty maintaining sleep (DMS) and early morning awakening (EMA), as well as sleep disturbance symptoms such as subjectively insufficient sleep and short sleep duration (<6 h), tended to be higher both among never-smoking adolescents with SHS exposure and among smoking adolescents, as compared with never-smoking adolescents without SHS exposure. When adolescents with one or more of DIS, DMS, and EMA were defined as having insomnia, the adjusted odds ratio for insomnia was highest for adolescents who smoked, followed in descending order by those exposed to SHS both inside and outside the home, those exposed to SHS only inside the home, those exposed to SHS only outside the home, and never-smoking adolescents without SHS exposure ($p < 0.001$).
Conclusions: The present study has revealed that SHS exposure is associated with sleep disturbance. Thus, in addition to smoking cessation programs, it is also necessary to endorse measures to protect adolescents from SHS exposure in order to promote good sleep in this population.

1. Introduction

Sleep disturbances include insomnia (such as difficulty initiating sleep [DIS], difficulty maintaining sleep [DMS], and early morning awakening [EMA]), subjectively insufficient sleep (SIS), and short sleep duration (SSD). These are associated with various problems, such as depression, anxiety [1–4], attempted suicide [5], poor academic performance [6,7], and substance abuse [8–10] (including smoking and drinking alcohol). Insomnia has been reported among 10.7–23.5% of adolescents in various countries [5,6,9–12], although the prevalence varies depending on the definition of insomnia and the survey method employed. The United States' National Institutes of Health has recommend an average sleep duration of 9–10 h for teenagers [13]. However, the reported actual sleep duration is approximately 8 h in Europe [11], 7.3 h in the US [2], 6.3 h in Japan [14], and 5–6 h in Korea [15]. Thus, sleep disturbance in adolescents is a serious public health issue.

Three mechanisms have been proposed to explain the effects of smoking on sleep: (1) nicotine in tobacco smoke stimulates the release of neurotransmitters involved in control of the sleep–wake

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cycle [16–18]; (2) nicotine withdrawal causes symptoms that prevent sleep [19]; and (3) smoking can cause diseases associated with airway obstruction, such as asthma, which may disrupt the continuity of sleep [20,21]. In addition, a cohort study reported that smoking could be a predictor of DIS and DMS in adolescents [22]. As both active and passive smoking result in exposure to the nicotine in tobacco smoke, exposure to second-hand smoke (SHS) may also affect sleep. Epidemiological associations between SHS exposure and sleep disturbance symptoms among adult men [23], pregnant women [24], and children with asthma [25] have been reported. However, few studies have assessed the associations between SHS exposure and sleep in adolescents. Although Schwartz et al., have reported dose–response relationships between SHS exposure and restless sleep and between SHS exposure and sleep duration [26], to our knowledge, no other study has evaluated the associations between SHS exposure and insomnia symptoms (DIS, DMS, and EMA) in adolescents.

According to the nationally representative Global Youth Tobacco Surveys (GYTS) conducted from 1999 to 2008 in 168 countries, approximately one-third and two-fifths of never-smoking adolescents were exposed to SHS inside and outside their homes, respectively [27]. SHS exposure depends on the presence of smokers at places where individuals spend their time. At various stages of life (early childhood, adolescence, adulthood, etc.), the places where individuals spend their time changes. For example, adolescents spend most of their time in school, both while attending classes and participating in extracurricular activities. This distribution differs between adolescents and young children, although both are categorized as minors. It is important to clarify the status of SHS exposure and its effects on sleep among non-smoking adolescents in order to establish measures to remedy these conditions.

Therefore, the present study was performed to clarify the status of SHS exposure inside and outside the home among Japanese junior and senior high school students and to elucidate the associations between SHS exposure and sleep disturbance. This study is one of a series of nationwide surveys on lifestyle habits of Japanese junior and senior high school students, including alcohol consumption, smoking, eating, sleep, and school life, and was preceded by six surveys conducted in 1996 [28], 2000 [8], 2004 [9], 2008 [29], 2010 [10] and 2012 [30].

2. Methods

2.1. Participants

A single-stage cluster sampling method was employed. First, 10,547 junior and 4807 senior high schools (15,354 in total) in Japan were registered for this study in May 2013. Next, 140 junior high (selection rate: 1.3%) and 124 senior high (selection rate: 2.6%) schools (a total of 264 schools, selection rate: 1.7%) were randomly selected. Probability-proportional-to-size sampling was employed such that the probability of selection was determined in proportion to the number of enrolled students. The sample size was determined based on the school response rates and 95% confidence intervals for the prevalence of alcohol consumption and smoking that had been observed in our previous nationwide surveys on lifestyle habits of junior and senior high school students (op.cit.).

In the Japanese education system, children enter primary school at six years of age for six years of education. Students then attend junior and senior high schools for three years each.

2.2. Survey procedure

The principal of each selected school was sent a package containing a letter requesting cooperation with the survey, as well as enough questionnaires and envelopes for the students enrolled in the school at that time. At each school where the principal approved participation, homeroom teachers delivered the questionnaires to the students. To safeguard student privacy and to obtain frank responses, the teachers were requested to abide by explicit guidelines. In addition, each questionnaire stated that the completed questionnaire would not be seen by the teacher. All of the students were requested to place their completed questionnaire in the supplied envelope and seal it with an adhesive flap. The sealed envelopes were returned to the School of Medicine of Nihon University. The survey was conducted between October 2014 and March 2015. This study was approved by the Ethics Committee of Nihon University School of Medicine.

2.3. Response rates

This study included 65,688 and 99,581 students enrolled in 140 and 120 randomly selected junior and senior high schools, respectively (a total of 165,269 students in 260 schools). Among them, 79 junior high and 77 senior high schools (156 in total) participated in the survey. The school cooperation rates were 56.4% and 64.2% for junior and senior high schools, respectively (overall rate: 60.0%). The total number of junior and senior high school students who responded were 31,769 and 54,162, respectively (85,931 in total). The response rates were 48.4% and 54.4%, respectively (overall rate: 52.0%). From the collected questionnaires, 943 were excluded because sex was not specified or the responses were inconsistent. Data from the remaining 84,988 questionnaires (31,474 and 53,514 from junior and senior high schools) were analyzed. The effective response rates were 47.9% for junior high and 53.7% for senior high schools (overall rate: 51.4%). The basic characteristics of the included respondents are shown in Table 1.

2.4. Measures

The questions included in the questionnaire were created based on those used in our previous nationwide surveys. First, with regard to smoking status, the following question was added to the questionnaire:

"Which best describes your current smoking status?"

The answer options were as follows: I have never smoked; I have previously smoked, but do not currently smoke; I sometimes smoke; and I smoke often. Those who selected "I have never smoked." were defined as never-smoking adolescents, while those who selected other responses were defined as smoking adolescents.

The possible responses to the questions, "During the past week, on how many days have people smoked in your home, in your presence?" and, "During the past seven days, on how many days have people smoked in your presence, in places other than in your home?" included 0, 1–2, 3–4, 5–6, and 7 days. Those who selected one day or more in response to the above questions were categorized as having been exposed to SHS inside or outside the home. The above questions regarding SHS and the dichotomized measures were the same as those used in the GYTS [27].

With regard to sleep status, the following questions were added to the questionnaire in order to investigate whether the participants had experienced corresponding insomnia symptoms in the previous 30 days:

"Do you have difficulty falling asleep at night?" (DIS), "Do you wake up during the night after you have gone to sleep?" (DMS), and "Do you wake up too early in the morning and have difficulty getting back to sleep?" (EMA).

The following five response options were provided: never, rarely, sometimes, often, and always. Those who selected often and always for each question were defined as having each insomnia symptom (DIS, DMS, and EMA). Those with one or more of the three insomnia symptoms were defined as having insomnia. These definitions have also been used in other reports [6,9,10,29].