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The relationship between risk of obstructive sleep apnea and other sleep problems, depression, and anxiety in adolescents from a community sample

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ABSTRACT

Obstructive sleep apnea (OSA) is highly related to mental health problems, such as depression and anxiety. However, previous studies on OSA and depression and anxiety have mostly been conducted in the adult population. We aimed to (1) screen for risk of OSA in a sample of adolescents from the general population using self-report questionnaires and (2) examine whether there are differences between the high- and low-risk groups for OSA in depressive and anxiety symptoms, self-esteem, and sleep-related variables.

The data of 793 students (age range: 12–17 years old) were analyzed. The participants were assigned to the high-risk (n = 202, 25.5%) or the low-risk group (n = 591, 74.5%) of OSA. The participants in the high-risk group had more severe anxiety symptoms, lower self-esteem, insomnia, excessive daytime sleepiness, and higher BMI compared those in the low-risk group. This study shows that it is possible to efficiently screen for risks of various problems associated with OSA in adolescents using an easy and simple screening tool.

1. Introduction

Obstructive sleep apnea (OSA) is characterized by repetitive collapse of the upper airway during sleep (Malhotra and White, 2002) and is the most common form of sleep-disordered breathing (SDB; Peppard et al., 2013; Senaratna et al., 2017). Predisposing factors for OSA that have been identified in previous studies include obesity, male, late adulthood, hypothyroidism, and certain anatomical characteristics of the face, such as large neck, large tongue, or short lower jaw (Hnin et al., 2018; Ho and Brass, 2011; Lowe et al., 1995; Tishler et al., 2003).

Although there has been robust research in OSA in adult and pediatric general populations, fewer studies have focused on the adolescent general population (Andersen et al., 2016; Baker et al., 2017; Patinkin et al., 2017). Among those studies, some have found that high BMI is the greatest risk factor for OSA (Gungor, 2014). Recently, the incidence of OSA has increased among adolescents due to the escalating prevalence of obesity. Marcus et al. (2012) reported a prevalence of OSA at 1–6%, and Spilsbury et al. (2015) presented that of 4.3% in the general adolescent population. Compared to these, the prevalence in obese children and adolescents ranged from 19 to 61% (Ørntoft et al., 2019).

Also, people with OSA often have oxygen desaturation in their arterial blood due to repetitive upper airway obstruction, which increases respiratory efforts and may disturb sleep quality (Malhotra and White, 2002). Poor sleep quality may lead to tiredness, fatigue, daytime sleepiness, and poor concentration. Furthermore, a lack of oxygen in the brain may cause physical health problems including cerebrovascular disease (e.g., heart failure, arrhythmia, and ischemic heart disease) and diabetes (Bradley and Floras, 2009; Punjabi, 2008; Vanderveken et al., 2011). Above all, OSA can lead to failure to thrive in childhood and adolescence, which is a serious problem (Leiberman et al., 1988; Marcus et al., 1994).

Many earlier studies have shown that not only physical health problems, but also various mental health problems can be comorbid with OSA. For example, almost half of adults with OSA experience psychological difficulties, such as anxiety and depression (Guilleminault et al., 1977; Reynolds et al., 1984). Children with OSA are more likely to have behavior problems such as attention–deficit hyperactivity disorder (ADHD) or aggression (Gozal, 1998; Marcus et al., 2013, 2012).

Despite a large body of evidence in this area, there are some limitations of previous findings regarding study population and

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relationships between OSA and psychological problems. First, although there have been many studies about OSA and psychological problems in adult or pediatric populations, there is a dearth of studies investigating OSA and psychological problems in adolescents. Thus, emotional problems such as depression and anxiety in adolescent populations remain largely unexplored despite their comorbidity. Most previous studies that investigated OSA and psychological issues investigated depression and anxiety in adult participants or attention deficit hyperactivity disorder (ADHD) in children participants. Second, polysomnography has been used as a standardized test for diagnosing OSA (Lopez-Jimenez et al., 2008). However, previous studies have encountered several problems with its use. For example, polysomnography is difficult to conduct because of its long duration and high cost. Therefore, earlier studies could recruit only a small sample of participants, which decreases the generalizability and statistical power of the results. To overcome such limitations, self-report questionnaires have been increasingly considered as an alternative way to screen for OSA (Mitchell et al., 2015; Rosen et al., 2015). For example, the Berlin Questionnaire, which was developed as an outcome of a conference in 1996 on Sleep in Primary Care involving 120 physicians, has been validated as an effective tool for identifying those at risk of OSA in several previous studies (Kang et al., 2013; Netzer et al., 1999; Sharma et al., 2006; Tan et al., 2017; Thurtell et al., 2011).

Considering the above, this study aimed to (1) screen for risk of OSA in a sample of adolescents from the community using a self-report questionnaire and (2) examine whether there are any differences in depressive and anxiety symptoms, self-esteem, and sleep-related variables between high- and low-risk groups of OSA.

2. Methods

2.1. Participants and procedures

A total of 827 participants was recruited from one middle school and one senior high school located in Seoul, South Korea. Following approvals for the present study from the school principals, detailed information about the study was given to participants, and written informed consent was obtained before the experiment. As a result, students between 7th and 11th grades (age: 12–17 years) volunteered to participate in this study. Of the 827 participants, 34 were excluded from the analyses due to incomplete responses, which resulted in a total of 793 participants for the final analysis. Of these participants, 310 were female (39.1%), and the mean age was 15.08 years (SD = 1.36 years). This study was approved by the Institutional Review Board (IRB) for Human Subjects at Seoul National University Hospital.

2.2. Measures

2.2.1. Berlin Questionnaire

The Berlin Questionnaire is a self-report questionnaire that identifies the risk of OSA and was developed at a conference in 1996 on Sleep in Primary Care involving 120 physicians (Netzer et al., 1999). This tool has shown great predictive value compared with other objective indices of OSA such as apnea–hypopnea index (AHI) and respiratory disturbance index (RDI; Kang et al., 2013; Sharma et al., 2006; Tan et al., 2017). Also, it is frequently used for predicting respiratory complications related to OSA during the perioperative period (Gokay et al., 2016). Furthermore, it has shown sound levels of sensitivity and specificity in community populations (Chung et al., 2008; Netzer et al., 1999). The questionnaire was validated in adolescents younger than 19 years who were severely obsese and underwent bariastric surgery (Ishman et al., 2016). Also, many studies have validated the questionnaire in a general population younger than 30 years, and it has been widely used in studies with adolescents and young adults (e.g., Bouloukaki et al., 2013; Chung et al., 2008; Migacz et al., 2017; Sharma et al., 2006).

In the Berlin Questionnaire, risk for OSA is measured based on the responses in three categories (Netzer et al., 1999). The first category involves five items related to snoring; when the total score of these items is two or higher, the category is judged as positive. The second category involves four items regarding daytime sleepiness and is also judged as positive when the total score is two or higher. The third category is judged as positive if the respondent has hypertension and/or body mass index (BMI) over 30 kg/m^2. Since only those who are 19 or older can obtain a driver's license in South Korea, the item “Have you ever nodded off or fallen asleep while driving a vehicle?” was deleted from this study, as in Kang et al. (2013).

In previous use of the Berlin Questionnaire, the respondent was classified as being at a high risk of OSA when two or more categories were scored as positive. However, for the current study, we categorized a respondent as the “high-risk group” if one or more categories were scored as positive and as the “low-risk group” if none were scored as positive. The purpose of this measure is to explore the characteristics of participants who are at a risk of OSA using more sensitive criteria, especially because category 3 involves hypertension or BMI equal to or higher than 30, which are relatively rare in adolescents. It has been also suggested that the Asian population use lower cut-off points in BMI due to differences in body build and muscle proportion (Deurenberg et al., 2002; Jih et al., 2014; Singh et al., 2012). Previous studies have also found that each category of the Berlin Questionnaire is highly related to sleep apnea, and that participants who satisfied even one category of the Berlin Questionnaire were at a higher risk for OSA (Ahmadi et al., 2008; Mustafa et al., 2005).

In Netzer et al. (1999), the Cronbach's α of the Berlin Questionnaire was .86 for category 1 and .92 for category 2. In the Korean version, it was .78 for category 1 and .82 for category 2 (Kang et al., 2013). For this study, the Cronbach's α was .685 for category 1 and .744 for category 2, and category 3 was one item.

2.2.2. Epworth Sleepiness Scale (ESS)

The ESS is a self-report questionnaire that is used to assess the level of daytime sleepiness. It involves eight items, and its score ranges from 0 to 24. The reliability and validity of the Korean version of the ESS have been confirmed, and it is commonly used in adolescent populations (Cho et al., 2011; Son et al., 2009). As the original author suggested, we categorized participants whose score was 11 or higher as the “excessive daytime sleepiness” group and those with a score lower than 11 as the “normal daytime sleepiness group” (Johns, 1991). Cronbach's α for the scale was .787 in the current study.

2.2.3. Insomnia Severity Index (ISI)

The ISI is a 7-item scale that measures insomnia symptoms, sleep satisfaction, interference with daytime functioning, awareness of impairment, and concerns about sleep problems (Bastien et al., 2001). On a 5-point Likert scale ranging from 0 to 4, respondents were asked to rate the severity of their insomnia symptoms over the past two weeks. As the original author suggested, we categorized participants with a score of 15 or higher as the “insomnia group” and those with a score lower than 15 as the “normal group” (Morin, 1993). This index has demonstrated a high level of internal consistency, with a Cronbach's alpha of .92 (Cho et al., 2014). For the current study, Cronbach's α was .795.

2.2.4. Children's Depression Inventory (CDI)

The CDI is a self-report scale that modified the Beck's Depression Inventory for use in children, and we used the Korean version of the scale (Cho and Lee, 1990). The CDI has been particularly used for children and adolescents from 7 to 17 years old. A total of 27 items can be rated from 0 to 2 points. Therefore, the total score can range from 0 to 54 points, and higher score implies higher level of depression (Kovacs, 1985). As in many previous studies, we categorized participants with a score of 13 or higher as the “high depression group” and

those with a score lower than 13 as the "low depression group" (Allgaier et al., 2012; Garvin et al., 1991; Kovacs, 1992). Cronbach's α for the scale was .822 in the current study.

2.2.5. Revised Children's Manifest Anxiety Scale (RCMAS)

The RCMAS is a self-report questionnaire that measures anxiety symptoms. It has been validated across countries including South Korea (Choi and Cho, 1990; March and Albano, 1996). The questionnaire consists of 37 items, with 28 items about anxiety and 9 items comprising the Lie Scale, which measures the validity of the result. All items are dichotomous with "yes (1)" and "no (0)" responses, and a higher total score indicates greater anxiety. As Montgomery and Finch Jr. (1974) and Go et al. (2016) suggested, we categorized participants whose score was 19 or higher as the "high anxiety group" and those with a score lower than 19 as the "low anxiety group." Cronbach's α for the scale was .877 in the current study.

2.2.6. Rosenberg Self-Esteem Scale (RSES)

The RSES comprises 10 items, and it is an instrument for evaluating the respondent's self-esteem. It has been reported to show consistent reliability and validity across diverse groups (Schmitt and Allik, 2005). The Korean version of the RSES is also widely used for evaluating self-esteem, with good reliability and validity (Lee et al., 2009). As Isomaa et al. (2013) suggested, we categorized participants whose score was 25 or higher as the "high self-esteem group" and those with a score lower than 25 as the "low self-esteem group." Cronbach's α for the scale was .702 in the current study.

2.3. Statistical analysis

Chi-square tests and Student's *t*-tests were conducted to compare demographic and clinical characteristics between participants in the high- and low-risk groups for OSA. Subsequently, one-way analyses of covariance (ANCOVA) were performed to control the effects of age and sex. Also, a series of chi-square tests was performed to compare the proportions of participants in the high- and low-risk groups for OSA who met the criteria for the clinical groups of other questionnaires that measure affect, personality, and sleep variables. Reliability analyses were conducted to obtain Cronbach's *α*s for the questionnaires. Statistical significance for all tests was set at $p < .05$. All statistical analyses were performed using SPSS 23.

3. Results

As shown in Table 1, 202 (25.5%) and 591 (74.5%) participants were assigned to the high- and low-risk groups, respectively. There was no significant difference in age between the two groups ($p = .140$). The high-risk group had 84 female participants (41.6%), while the low-risk group had 226 female participants (38.2%), and there was no significant difference in sex between the two groups ($p = .400$).

Participants in the high-risk group for OSA had significantly higher BMI, more anxiety symptoms, insomnia, and daytime sleepiness than those in the low-risk group ($p = .007$ for BMI; $p < .001$ for anxiety symptoms; $p = .043$ for self-esteem; $p < .001$ for insomnia; $p < .001$ for daytime sleepiness), but the two groups showed no significant difference in depressive symptoms ($p = .073$). Detailed data with statistics is presented in Table 1. The results remained significant after controlling for age and sex ($p < .001$ for BMI; $p < .001$ for anxiety symptoms; $p = .024$ for self-esteem; $p < .001$ for insomnia; $p < .001$ for daytime sleepiness; $p = .255$ for depressive symptoms).

Table 2 summarizes how many proportions of participants in the high- and low-risk groups met the criteria for clinical levels of BMI and each questionnaire. In BMI and all the questionnaires, higher proportions of participants in the high-risk group for OSA met the criteria for the clinical subgroups for depression, anxiety, low self –esteem, insomnia, and excessive daytime sleepiness ($p = .003$ for BMI; $p = .002$ for CDI; $p < .001$ for RCMAS; $p = .035$ for RSES; $p < .001$ for ISI; $p < .001$ for ESS).

Table 1
Demographic and clinical characteristics of the high- and low-risk group for obstructive sleep apnea.

Variables	High-risk group (n = 202) mean (*SD*)	*n*	Low-risk group (n = 591) mean (*SD*)	*n*	*t, F*	*p*
Age	14.94 (1.42)	195	15.11 (1.35)	565	–1.48	.140
BMI	21.49 (4.37)	171	20.49 (3.35)	499	2.72	.007**
CDI	15.29 (7.40)	192	14.18 (7.37)	556	1.80	0.073
RCMAS	12.95 (6.45)	200	10.16 (5.99)	576	5.54	<0.001***
RSES	26.17 (4.20)	185	26.92 (4.41)	560	–2.03	.043*
ISI	10.74 (4.55)	202	8.73 (3.94)	577	5.59	<0.001***
ESS	7.97 (4.32)	202	6.11 (3.91)	577	5.38	<0.001***

Abbreviations: BMI = Body Mass Index; CDI = *The Children's Depression Inventory*; RCMAS = *The Revised Children's Manifest Anxiety Scale; ISI = Insomnia Severity Index;* ESS = *Epworth Sleepiness Scale*.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

4. Discussion

This study investigated the relationships between risk of OSA and depression, anxiety, self-esteem, and other sleep-related problems in adolescents, an underrepresented population in the study of OSA and psychological difficulties. Although we adopted more lenient criteria for measuring risk of OSA, our findings were similar to those of previous studies with adult participants that adopted the original criteria and proportion of high risk for OSA. The prevalence of OSA in this study was quite similar to that in previous studies that used the definition of OSA as AHI ≥ 5 by the American Academy of Sleep Medicine Task Force (Franklin and Lindberg, 2015).

We found higher levels of depression and anxiety in adolescents with higher risk of OSA. This aligns with findings of previous studies on adults (Guglielmi et al., 2011; Guilleminault et al., 1977; Kjelsberg et al., 2005; Kripke et al., 1997; Lee et al., 2015; Macey et al., 2010; Ohayon, 2003; Peppard et al., 2006; Phillips et al., 1996; Pillar and Lavie, 1998; Rezaeitalab et al., 2014; Sharafkhaneh et al., 2005).

Possible explanations on why OSA is associated with depression and anxiety have been suggested. First, neural injury from inflammation caused by hypoxia has been suggested as a feasible pathway for developing depression and anxiety (Kerner and Roose, 2016; Sforza et al., 2002). Elevated levels of IL-6 and TNF-alpha have been observed in people with OSA, which can induce neurotoxicity and cause injury to the noradrenergic and dopaminergic systems, which are closely related to mood control. The second explanation is "hypothalamic-pituitary-adrenal (HPA) axis dysfunction," which can be a consequence of hyperactivation of the HPA axis caused by sleep apnea (Buckley and Schatzberg, 2005). Similarly, previous studies on the association between OSA and anxiety have suggested that frequent fragmented sleep and/or increased sympathetic tone caused by hypoxia increase anxiety (Kjelsberg et al., 2005).

One of our main findings indicates that adolescents with a higher risk of developing OSA were more likely to have symptoms of insomnia. This finding aligns with main findings of a previous study that found a higher incidence of insomnia in patients with OSA (Krell and Kapur, 2005). As suggested by some earlier studies, it is possible that other relevant psychological and behavioral factors (e.g., beliefs about sleep, anxiety, pre-sleep arousal) might have contributed to more severe insomnia in participants of the high-risk group (Yang et al., 2010). As mentioned, combination of altered HPA-axis function and obesity has been commonly reported in people with OSA, insomnia, and depression (Balbo et al., 2010; Kupfer et al., 1993; Vgontzas et al., 2007).

Table 2
Distribution of participants in the high- and low-risk groups for obstructive sleep apnea by clinical subgroups in each questionnaire.

Questionnaire	Clinical subgroups	High-risk group	Low-risk group	χ^2 (p)
BMI	Overweight	17.5%	9.2%	8.78 (.003**)
CDI	Depressed	65.6%	52.5%	9.95 (.002**)
RCMAS	High anxiety	18.5%	9.0%	13.12 (< .001***)
RSES	Low self-esteem	66.5%	74.5%	4.44 (.035*)
ISI	Having insomnia	21.3%	9.0%	21.05 (< .001***)
ESS	Excessive daytime sleepiness	26.2%	12.0%	23.10 (< .001***)

Notes. BMI = *Body Mass Index*, cut-off ≥ 25; CDI = *The Children's Depression Inventory*, cut-off ≥ 13; RCMAS = *The Revised Children's Manifest Anxiety Scale*, cut-off ≥ 19; RSES = *The Revised Children's Manifest Anxiety Scale*, cut-off ≥ 25; ISI = *Insomnia Severity Index*, cut-off ≥ 15; ESS = *Epworth Sleepiness Scale*, cut-off ≥ 11.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Also, we found that participants with a high-risk of OSA had higher BMI than those with low-risk. Therefore, these factors might also have played roles in the relationships.

OSA has been reported to be one of the most common comorbid conditions in adolescents with severe obesity, with a prevalence up to 60% (Verhulst et al., 2008). In a group of obese people (i.e., BMI ≥ 40), the risk of OSA increased by 12% as BMI increased by 10% (Kalra et al., 2005). Furthermore, obesity in children and adolescents is closely related to lower self-esteem (Rankin et al., 2016; Strauss, 2000).These findings are corroborated with the results of this study that the high-risk OSA group had higher BMI and lower self-esteem compared to the low-risk group.

This study has several limitations. First, the relatively large size of the high-risk group using the criteria our study adopted can stem from participants who were positive in one of the categories. Daytime fatigue in the category 2 can be derived from mental health conditions such as anxiety, depression, or other sleep disorders. Despite the possibility that this might corrode our findings, a higher prevalence of tiredness or sleepiness would decrease the specificity of categorization of high risk for OSA but not likely the sensitivity, as Ahmadi et al. (2008) argued. Second, we used the Berlin Questionnaire, which is a self-report questionnaire, to measure the risk of developing OSA, although polysomnography is the gold standard for measuring OSA. However, the Berlin Questionnaire has been well-known for its high sensitivity and specificity. Our main findings also align with main findings of other previous studies that used polysomnography. Third, our key findings do not provide evidence about a causal relationship among OSA, sleep problems, BMI, depression, and anxiety due to the nature of our cross-sectional study design. Finally, since our participants were recruited from one middle and high school in Seoul, South Korea, there might be issues of generalizability.

Still, the results of this study can be clinically useful for the following reasons. First, to our knowledge, this is the first large-scale community-based study targeting adolescents with risk for OSA and psychological problems. Most previous studies that investigated OSA and psychological issues have mainly targeted adult and pediatric populations. Secondly, we added evidence that the Berlin Questionnaire is an easily accessible tool to screen for risk of OSA, considering the limitations of polysomnography. Findings from our study can help provide early and efficient screening and allow timely interventions for adolescents at risk of developing OSA. They may also prevent various issues that can arise from the syndrome, such as brain damage, disturbance in development, emotional difficulties, and reduced academic performance. Thus, more research on OSA and psychological issues in adolescents with reliable and valid self-report measures is needed.

Ethics approval and consent to participate

The Institutional Review Board (IRB) for Human Subjects at Seoul National University Hospital approved the study (No. C-1412-081-633), and participants and their parents provided informed consent prior to enrolment.

Declaration of Competing Interest

The authors declare that they have no conflicts of interests.

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