

# The epidemiology of sleep behavior, physical activity, and depression : A review of the literature

Supartini, Atin

Department of Behavioral and Health Science, Graduate School of Human-Environment Studies, Kyushu University

Kumagai, Shuzo

Department of Behavioral and Health Science, Graduate School of Human-Environment Studies, Kyushu University | Faculty of Arts and Science, Kyushu University

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—Review—

# The epidemiology of sleep behavior, physical activity, and depression: A review of the literature

Atin SUPARTINI<sup>1)</sup> and Shuzo KUMAGAI<sup>1,2)\*</sup>

## Abstract

The aim of this study is to review the literature on the epidemiological studies of sleep behavior, physical activity and depression. Based on the reviewed literature, depression has been linked to sleep-related factors; sleep disturbances, sleep quality, sleep quantity and sleep timing. Similar to western findings, numerous epidemiological studies conducted in Japan have identified sleep disturbances as a significant risk factor for the later development of depression. However, the epidemiology studies on the relation between sleep timing, sleep quality and depressive symptoms are few and mostly cross-sectional designed. Therefore, this study is warranty and timely. Furthermore, the combination of sleep and physical activity in relation to depression remains unclear.

**Key words:** sleep behavior, physical activity, depression

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## Introduction

Depression is considered as one of the most common mental health throughout the world, and is projected to become the second leading cause of disability by 2020.<sup>1)</sup> In Japan, depression becomes a serious public health concern that is predicted to be the leading cause of the burden of disease and a rapid increase in suicides.<sup>2, 3)</sup> According to the National Police Agency of Japan (2010a, 2009)<sup>4, 5)</sup>, the number of suicide deaths was six times higher than the number of deaths in traffic accidents in the year 2009, and two thirds of the reason-specifiable cases were attributable to mental health issues such as depression.

Sleep and physical activity (PA) are amongst

modifiable lifestyle behavior which is associated with depression.<sup>6,7)</sup> For example, a meta-analysis study suggested that the duration of sleep outside the normal range increases the genetic chances of depressive symptoms.<sup>8)</sup> Additionally, Teychenne et al. (2008) found that regular physical exercise significantly decreases the risk for developing depression in adult populations.<sup>9)</sup>

The aim of this study is to review the literature on the epidemiological studies of sleep behavior, physical activity and depression. Through reviewing the literature, we also examined the potential physical activity on mediating the relation between sleep and depression.

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1) Department of Behavioral and Health Sciences, Graduate School of Human-Environment Studies, Kyushu University, Kasuga, Japan.

2) Faculty of Arts and Science, Kyushu University, Kasuga, Japan

\*Correspondence to: Faculty of Arts and Science, Kyushu University, 6-1 Kasuga-koen, Kasuga City, 816-8580, Japan.

Tel & Fax: +81-92-583-7853, E-mail: shuzo@ihs.kyushu-u.ac.jp

### **Sleep behavior and depression are bidirectionally related**

A substantial body of research has investigated the influence of depression on sleep quality.<sup>10)</sup> However, the relationship between these two factors is recently thought to be bidirectional,<sup>11)</sup> and the evidence supporting the impact of sleep on depression is growing.

A study by Kim et al. (2001) found that insomnia was significantly associated with a number of mental illnesses such as fatigue, worrying, irritability, and loss of interest.<sup>12)</sup> Additionally, poor sleep quality was found to predict depressive symptoms among freshmen.<sup>13)</sup> Furthermore, two nationwide large epidemiologic studies by Kaneita et al. (2006 & 2007) examined the relationship between sleep disturbances and mental health in general population.<sup>14, 15)</sup> The above studies have been conducted in different countries, and we found that the association between sleep disturbances and depression seems to be currently irrespective of culture. To that end, sleep disturbance and poor sleep quality have been theorized to contribute to depression.

While the association of sleep disturbances with depression has been documented before, various studies have also reported an association between depression and sleep behavior such as sleep timing, sleep quality, and sleep quantity<sup>13)</sup>. A chronobiological study suggested a correlation between circadian rhythm, a 24 h day-to-night cycle, and depression<sup>16)</sup>. Chronotype, which refers to the timing of sleep and regular activities has been suggested to affect circadian rhythm. In other clinical studies, the evening-type chronotype (late bedtime) was associated with a greater risk of depressive symptoms<sup>17)</sup> and of suicide<sup>18)</sup>.

Despite these evidences, relatively, few

epidemiological studies have investigated the association between sleep timing (bedtime and wake-up time), sleep quality, and depressive symptoms. For instance, an epidemiology study conducted in the United States found an association between earlier parental set bedtime and depression among adolescents<sup>19)</sup>. To our knowledge, few epidemiological studies on sleep timing in relation to depressive symptoms were conducted in Japan. There are four cross-sectional studies with different populations that showed a positive association between bedtime and depressive symptoms. At first, Sakamoto et al. (2013) conducted a study on depressive symptoms among workers<sup>20)</sup>. Second, an epidemiologic study was conducted amongst ronin-sei and university students by Sakamoto et al. (2013)<sup>21)</sup>. Third, Supartini et al. (2016) conducted a study on the relationship of sleep timing, sleep quality and depressive symptoms<sup>13)</sup>. At last, Kitamura et al.(2010) showed that a relatively late bedtime (after 0:00) was associated with an increased prevalence of depressive symptoms. However, the association was largely attenuated after adjusting for sleep duration<sup>22)</sup>. Since bedtime and sleep duration is closely related, Sakamoto et al (2013) assumed that sleep duration is a mediator, rather than a confounder, linking late bedtime to depressive symptoms. Thus, analysis without adjustment for sleep duration would provide a better estimate of the true association between late bedtime and depressive symptoms compared to analysis with sleep duration adjustment<sup>21)</sup>.

Taken together, the extant literature provides significant support of the impact of sleep behavior on depression, suggesting that the relation between sleep and depression to be bi-direction. However, due to the fact that epidemiological studies on the association between sleep timing and sleep quality

are few, further epidemiologic studies on the relationship between sleep timing, sleep quality and depressive symptoms are warranted. In addition, these studies are mostly cross-sectional studies, a prospective study is, therefore, required to confirm the results.

### **Physical activity and depression**

Several studies examining observational and intervention studies in western population have assessed the relationship between PA and depression or depressive symptoms<sup>23, 24</sup>. For example, De Mello et al. (2013) suggested that people who do not engage in PA are two times more likely to exhibit symptoms of depression and anxiety compared with those who regularly practice PA<sup>23</sup>. Feng et al. (2014) found that higher level of PA was independently associated with significantly lower risks for depression after adjusting for potential confounders<sup>25</sup>. In short, these reviews generally draw a similar conclusion that PA is positively associated with reduced likelihood of depression or depressive symptoms<sup>25</sup>.

Guidelines for the treatment of depressive disorders developed by the Japanese Society of Mood Disorders recommend exercise three or more times per week for mild depressive disorders<sup>26</sup>. Following this recommendation, a recent epidemiology study in Japan revealed that sufficient PA level was found to be related to lower risk of depressive symptoms<sup>27</sup>. Likewise, a large cohort study conducted amongst Japanese workers aged 20–64 years found that leisure exercise showed a U-shaped association with risk of depressive symptoms adjusting for potential confounders<sup>28</sup>. Kuwahara et al. (2015) found that individuals who engaged in sedentary work had lower risk of depression compared with individuals who stand or walk during work<sup>28</sup>.

In contrast with these findings, Yoshikawa et al. (2016) did not find any significant direct association between exercise and depressive symptoms,

suggesting that exercise to be indirectly associated with depressive symptoms through social support and resilience<sup>29</sup>. In conclusion, in consistent with western findings, most of Japanese epidemiology studies have suggested that PA is associated with decreased likelihood of depression.

### **Sleep and physical activity**

PA has consistently been linked to improve sleep quality. Previous epidemiologic studies in the United States have reported a reduced risk of sleep disorder in association with PA<sup>30</sup>, even though, a longitudinal study showed that additional adjustment for body mass index (BMI) attenuated the association<sup>30</sup>.

While most of researches have emphasized the effect of PA on sleep, the relationship between the two factors has been projected to be bidirectional<sup>31</sup> and a growing literature supports the effects of sleep on PA. For example, Shechter et al. (2014) suggested that sleep timing may influence physical activity level<sup>32</sup>. Olds et al. (2011) found that late bedtime and wake time are associated with lower moderate to vigorous PA (MVPA) levels compared to earlier sleep timing in adolescents<sup>33</sup>. Talbot et al. (2014) found that poor sleep quality predicts lower physical activity, providing possible evidence for a behavioral pathway from disturbed sleep to poor physical health outcome<sup>34</sup>. Chaput et al. (2013)<sup>35</sup> and Baron et al (2011)<sup>36</sup> have explained the link between delayed sleep and lower PA through energy balance mechanism.

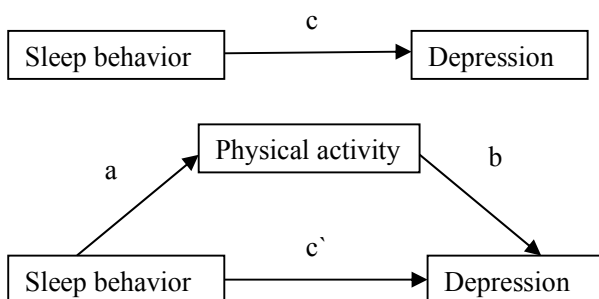
To our knowledge, only one epidemiological study conducted in Japan which suggested sufficient sleep to be associated with increased levels of physical activity<sup>37</sup>. Due to differences in lifestyle and culture, findings obtained in Western countries might not be applicable to Asian populations, Japan in particular. Therefore, an epidemiological study on the impact of sleep on physical activity remains warranty.

**Table 1. Summary table of epidemiological studies examining the association between sleep and depression in Japan**

Author	Target population	No of sample	Study design	Results
Sakamoto et al. (2013)	Employees	1197	Cross-sectional study	Sleep duration (<6 hours) and late bedtime were significantly associated with an increased prevalence of depressive symptoms.
Kaneita et al. (2006)	General population	24,686	Cross-sectional study	Sleep duration (< 6 hours and > 8 hours) and sleep sufficiency were associated with depression.
Fushimi (2015) <sup>39)</sup>	employees	1476	Cross-sectional study	Sleep duration (6 hours) was associated with depressive symptoms.
Atin Supartini et al. (2016)	Freshmen	1992	Cross-sectional study	Late bedtime (later than 01:30), sleep-onset latency ( $\geq 30$ minutes), and poor sleep quality showed a marginally significant association with depressive symptoms. Poor sleep quality was seen to predict suicidal ideation even after adjusting for depressive symptoms.
Matsushita et al. (2014)	Ronin-sei and University student	1360	Cross-sectional study	Sleep duration ( 5 to <6h and > 8 hours) had higher depression scores.
Kaneita et al. (2009)	Junior high school student	516	Prospective study	Sleep disturbance was associated with poor mental health
Nakata (2011)	employees	2643	Cross-sectional study	Sleep duration (< 6 hours) and reporting insufficient sleep were more likely to be depressed
Furihata et al. (2015)	General population	2532		Short sleep duration (<6 h) and short time in bed (<6 h) were significantly associated with CES-D depression
Kaneita et al. (2007) <sup>40)</sup>	Junior and high school student	99,668	Cross-sectional study	Sleep duration (< 7 hours, and > 9 hours or more) was associated with poorer mental health.
Asai et al. (2006) <sup>41)</sup>	General population	28,714	Cross-sectional study	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakening, insomnia, short sleep duration, and subjective insufficient sleep were higher amongst those who had psychological complaints

### Sleep, physical activity and depression

Based on the above literature review, it is clear that both sleep and physical activity have been shown to account for depression. However, an area that appears to be less explored is the potential interaction between sleep and PA that may lead to predict depression symptoms. To our knowledge, no study has examined yet the mediation or moderation effect of PA in relation with sleep and depression. According to Baron and Kenny (1986), if the four conditions as shown in fig. 1 are fulfilled, we may assume that PA would mediate or moderate the relation between sleep behavior and depression<sup>38</sup>. Subsequently, further research is necessary to examine this association.



**Fig. 1 The mediation model for sleep behavior, physical activity, and depression. Path ab is an indirect effect, and path c' is a direct effect.**

### Conclusion

The present literature review found that depression has been linked to sleep-related factors such as sleep disturbances, sleep quality, sleep quantity, and sleep timing. However, we noticed that epidemiological studies, which have been conducted in Japan, had mostly identified the relationship between sleep disturbances and depression (table. 1). The Epidemiology studies on the relation between sleep timing, sleep quality and depressive symptoms were few. Furthermore, these studies have limitation on its sample population and its cross-sectional design. Therefore, further

prospective studies are warranty.

In addition, the literature on the relationship between sleep and PA has been examined independently. Yet, the combination of sleep and PA in relation to depression remains unclear.

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