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Original Article

A Longitudinal Study on Psychosomatic Stress Reactions: Possible Roles of Lifestyle and Sleep in Resilience

Akiyoshi SHIMURA[1,2,3], Yoshiki ISHIBASHI[3,4], Katsunori YOKOI[3,5], Tomoki NISHIKAWA[2], Shohei MISAKI[2], Asami OSHIMA[2], Yuka IMAIZUMI[6], Yuji FURUI[7], Takeshi INOUE[1]

1 Department of Psychiatry, Tokyo Medical University
2 Sakurajyuji Medical Corporation
3 Department of R & D, Children and Future Ltd.
4 Department of Preventive Medicine and Public Health, Keio University School of Medicine
5 School of Medicine, International University of Health and Welfare
6 School of Medicine, Tokyo Medical University
7 Institute for Future Initiatives, the University of Tokyo

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Abstract

[Introduction] Although mental health care is important, at present, effective preventative methods for mental disfunction are underdeveloped. Mental health problems can be caused by psychological factors such as job stressors and stressful life events. Recently, the association of lifestyle and sleep with mental health has gained attention; however, few studies have comprehensively investigated multiple lifestyle factors and sleep while controlling for job stressors in office workers. We performed a longitudinal study to clarify the effects of lifestyle and sleep factors on the mental health of office workers.

[Materials and Methods] In 2017, 3,314 employees from 17 companies were invited to participate in the survey. Complete responses and informed consent were provided by 2,905 participants, and of those, 2,289 participants answered the survey again in 2018. The effects of the participants' lifestyle and sleep on their current psychosomatic stress reactions were analyzed by multiple linear regression and a cross-lagged model by structural equation modeling.

[Results] When controlled for job stressors or social support, commuting time, irregular mealtimes, not eating vegetables daily, alcohol intake, not seeing morning sunlight in the bedroom, dinner within 1 hour before bedtime, using electronic devices before bed or in bed, nighttime caffeine intake, and sedentary behavior were associated with changes in psychosomatic stress reactions. The cross-lagged model demonstrated that the degree of estimation from a participant's previous lifestyle factors or sleep disturbance to current stress reactions were greater than that from previous stress reactions to current lifestyle factors or sleep disturbance.

[Conclusion] Lifestyle problems and sleep disturbance led to psychosomatic stress responses independently from controlling factors such as job stressors. Therefore, improving lifestyle factors and sleep factors associated with stress reactions may be a primary prevention method for mental health dysfunction.

Keywords: lifestyle, sleep, resilience, mental health, preventative medicine

Introduction

Improving mental health and preventing mental health disorders are important and urgent issues not only for psychiatry but also for public health. The suicide rate in Japan continues to be one of the worst among developed countries,[41] and this rate, which had been declining since peaking in the 2000s, has recently stopped decreasing and is expected to increase by 2020.[26] Even among employed people, the number of work-related accidents due to mental disorders continues to increase,[25] and unfortunate incidents continue to occur.

The methodology for preventing mental health problems is still in its infancy. Although effective suicide prevention measures are still being sought both in Japan and overseas,[11,42,56] many investigations have focused on clinical and early interventions, with few effective interventions for groups or primary prevention. In Japan, a psychological stress check system has

been in place since 2015 to assess the level of psychological distress as a tool for understanding workers' mental health. However, even if workers are able to identify their own mental health problems, they often lack knowledge of how to reduce them.

Mental health problems are not caused solely by psychological stress, such as life events or work-related stress. There are other factors related to mental and physical health and illness, and in recent years, the relationship with lifestyle, such as sleep and diet, has been cited. If sleep and lifestyle are the "causes" of mental health problems, then improving these factors could be a form of primary prevention for mental health problems. In addition, even if some kind of problem has already occurred, but it is not possible to immediately provide clinical intervention or reduce psychological stress, this could be a way to reduce the problem as self-care and prevent it from progressing. It is often difficult for both the sufferer and third parties to immediately identify or resolve psychological problems. In addition, it is difficult to intervene with groups because of the inherent issues of individuality and privacy, and because lifestyle habits are universal phenomena, it is possible to address, intervene, and raise awareness of them without encountering privacy issues, so it may be useful as a measure for primary prevention of mental health problems involving groups.

Cohort studies in Japan have shown that a healthy diet, characterized by the consumption of vegetables, fruits, and fish, is associated with suicide rates, with the risk being about twice as high in an unhealthy compared with a healthy group.[36] In addition, multiple studies and meta-analyses have similarly shown an association between the consumption of healthy foods and depression.[27-29)32)37)38] Several studies have shown that exercise has a positive effect on improving or preventing mild to moderate depression,[44] and it is also known to have a positive effect on suicidal ideation and suicide attempts,[8)22)53] as well as anxiety.[5)48)49] Sleep is also a factor that is strongly linked to mental health. Sleep deprivation and disorders can cause structural damage to the brain, such as destruction of the microstructure of nerves[3] and inhibition of neurogenesis via the hypothalamic-pituitary-adrenal axis (HPA axis).[12] Sleep problems have consistently been shown to be a strong risk factor for depression and anxiety disorders.[2)15)30)40)58]

However, there are various problems with these studies when considering the impact of lifestyle on mental health. Firstly, many studies lack control for potential confounding factors. For

example, it is easy to assume that when work becomes excessive and overtime increases, sleep time decreases and breakfast may be skipped, but unless these two factors are analyzed simultaneously, it is impossible to determine whether it is work-related stress or sleep or lifestyle that has a direct impact on mental health. In addition, many studies have only looked at a single lifestyle item, so it is unclear which of the many lifestyle items are really important regarding mental health. Thus, if a person "doesn't eat vegetables, skips breakfast, drinks alcohol every day, doesn't exercise, and has poor sleep quality," it is not realistic to encourage them to improve all of these things from the start, but there is currently no way of knowing which of these is most important for their mental health. Although some studies have adjusted for these issues,[17) 39) 51) 55)] these are cross-sectional studies, and the causal relationship between whether a poor lifestyle affects mental health, whether mental disorders cause a poor lifestyle, or whether both are the cause is unclear. To date, no longitudinal studies have comprehensively examined multiple lifestyle factors in office workers while controlling for occupational factors. Therefore, in this study, we conducted a longitudinal survey to investigate the extent to which lifestyle factors, such as sleep and diet, affect the mental health of office workers.

I. Methods

1. Subjects

In 2017, we conducted a questionnaire survey involving a total of 3,314 employees at 17 workplaces in Tokyo, and obtained consent and valid responses from 2,905 (87.7%) of them. These workplaces included trading firms, IT companies, game production companies, restaurants, staffing agencies, broadcasting companies, financial companies, healthcare companies, consulting companies, video production companies, government offices, apparel companies, printing companies, music production companies, chemical companies, and trading companies. Although industrial and manufacturing companies were included, this survey was conducted at offices in Tokyo, and the respondents were basically office workers. Of these participants, 2,289 (69.1%) who responded to the same questionnaire the following year, 2018, were the subjects of the study.

The data in this study were anonymized at the data collection stage, making it impossible to identify individuals. This study was conducted with the approval of the Medical Ethics Review Committee of Tokyo Medical University (Approval No.: SH3652).

2. Questionnaire

The questionnaire consisted of demographic data (sex, age, marital status, and residential status), work-related questions (overtime hours, commuting time, job description, and major lifestyle changes in the past year), the Brief Job Stress Questionnaire (BJSQ),[24)45)] the Pittsburgh Sleep Quality Index (PSQI),[6)9)] and comprehensive lifestyle assessment items.

BJSQ is a Likert scale that consists of the following three sections: Section A, which consists of 17 questions to assess job stressors such as quantitative workload and work relationships (score range: 17-68 points); Section B, which consists of 29 questions to assess physical and mental stress reactions, including liveliness, irritability, fatigue, anxiety, depression, and physical complaints (score range: 29-116 points); and Section C, which consists of 9 questions to assess support from surrounding people, such as at work, family, and friends (score range: 9-36 points). There are also two questions to assess job and life satisfaction. In this study, the total score for each item was used, and a higher item score indicates a stronger job stress factor, a stronger psychosomatic stress responses, and weaker support from the surrounding environment.

PSQI is a scale that evaluates the degree of sleep problems (sleep disturbance) and consists of seven components: subjective quality of sleep (C1), latency to fall asleep (C2), sleep time (C3), sleep efficiency (C4), sleep difficulties (C5), use of sleep medication (C6), and daytime dysfunction (C7). Each item (called a component) is scored between 0 and 3 points, and the higher the total score (called the global score, with a score range of 0 to 21 points), the more disturbed the sleep, and in the Japanese version, a score of 6 or more is considered to indicate "poor sleeper/existence of sleep disturbance."

With regard to lifestyle habits, the following questions were asked regarding the situation in the past month: Irregularity of meal times, whether breakfast was skipped, dinner time (more than one hour before bed/within one hour of bed/skipped), frequency of eating vegetables, mushrooms, and seaweed (vegetables) (every day/less than every day), frequency of drinking alcohol (never/occasionally/every day), amount of alcohol drunk per week (equivalent to drinks), whether they have a regular exercise routine, the proportion of time spent sitting during the day, whether their bedroom is bright with morning sun when they wake up, the time of day when they last used electronic devices or screens (more than an hour before

bed/use right up until going to bed/use even in bed), and the frequency of consuming caffeinated beverages at night (never/sometimes/every day).

II. Analysis

First, we checked the basic statistics for the distribution of the population, and then we investigated the differences in total scores for BJSQ's psychosomatic stress responses in each year due to sleep problems and lifestyle habits using the t-test, Pearson's correlation coefficient, or one-way ANOVA.

Next, as multivariate analysis, we conducted multiple regression analysis with lifestyle as the explanatory variable and various factors such as demographic data and work stress factors as control factors, using the difference (increase or decrease) in the previous year's psychosomatic stress responses or that in the following year's survey as the objective variable, and clarified the impact of the lifestyle of the previous year on the psychosomatic stress responses of that year and the increase or decrease in the psychosomatic stress responses one year later, while controlling for work conditions, etc. In addition, based on the regression coefficients obtained from the multiple regression analysis, a composite variable (lifestyle score related to mental health) was created that reflected the degree of influence that each lifestyle factor had on fluctuations in mental health. In multiple regression analysis, which was conducted using the variable reduction method, the input criterion was set at $P<.10$ and exclusion criterion was set at $P<.05$.

Finally, we created a cross-lagged effects model to estimate causal relationships, and examined whether sleep problems and lifestyle caused subsequent deterioration or improvement in mental health, or whether the mental health status affected subsequent sleep and lifestyle, and whether it was the cause or effect, or if it was both, and what the proportions of each were. The cross-lagged effects model is one of the methods for analyzing longitudinal panel data using path analysis (structural equation modeling). It is possible to calculate the degree of causality using the fact that time flows from the past to future, and future factors cannot be the cause of past factors, so the direction of the path is fixed in one direction in principle[13] (Figure 1).

The goodness of fit of the path analysis model was assessed using existing criteria, with the criteria for "good fit" being: $\chi 2$ is non-significant ($P> .05$), goodness of fit index (GFI) > .95, adjusted GFI (AGFI) > .90, comparative

fit index (CFI) > .97, normal fit index (NFI) > .95, and root mean square error of approximation (RMSEA) < .05.[43]

IBM SPSS version 23 and IBM SPSS Amos version 22 were used for the analysis, and a 95% level of significance was adopted.

III. Results

1. Basic statistics and comparison

Of the 2,289 participants, 1,502 (65.6%) were male, 781 (34.1%) were female, and 6 (0.3%) were other or did not respond, with a mean age of 37.5 ± 9.2 (standard deviation) years. The average overtime hours per month was 24.9 ± 27.0 hours, average score for work-related stress factors was 38.9 ± 6.3 points, average score for support from colleagues was 19.7 ± 5.3 points, and average score for psychosomatic stress responses was 56.2 ± 13.7 points. The status of other variables, as well as the results of comparisons between each variable and the average value of the previous year's psychosomatic stress responses, and the difference between the average psychosomatic stress responses of the current and previous years, are shown in Table 1.

2. Multivariate analysis controlling for various factors

The results of multiple regression analysis, in which the objective variable was the psychosomatic stress responses the next year (T1), and the explanatory variables were lifestyle and sleep problems in the next year (T1) and previous year (T0), and further controlled factors such as sex, age, and work situation, are shown in Table 2.

In the model in which variables were reduced using the method of reducing variables, lifestyle factors such as commuting time that year (regression coefficient = .025 pt/min, standardized regression coefficient (β) = .045), irregular mealtimes (2.784 pt, β = .082), not eating vegetables every day (3.288 pt, β = .093), occasional drinking (–1.281 pt, β=-.039), not getting morning sunlight in the bedroom (1.667 pt, β=.056), using electronic device displays immediately before bed (1.377 pt, β=.048), consuming caffeine every night (1.423 pt, β = .049), irregular meal times in the previous year (1.573 pt, β = .046), sedentary behavior time in the previous year (4.622 pt/% time/day, β = .061), and using electronic device displays in bed (1.828 pt, β = .059), were the items that affected stress responses even after controlling for various factors. This model explained 42.8% of the variation in stress responses in the following year ($F=82.449$, $P<.001$, adjusted $R2=.428$).

Regarding the impact of lifestyle on improvements or deterioration in mental health, the results of multiple regression analysis are shown in Table 3, with the difference between the total

scores for psychosomatic stress responses in the current year and previous year as the dependent variable, lifestyle in the previous year as the explanatory variable, and sex, age, work situation, etc., and the score for stress responses in the previous year as the controlling factors. After reducing the variables using the variable reduction method, commuting time (.016 pt/min, β=.034, *P*=.084), irregular mealtimes (1.670 pt, β=.049, *P*=.007), dinner within 1 hour before bedtime (1.410 pt, β=.038, *P*=.056), not eating vegetables every day (1.369 pt, β=.047, *P*=.019), occasional drinking (1.079 pt, β=.040, *P*=.093), sedentary behavior time (2.382 pt, β=.038, *P*=.048), and not being exposed to the morning sun in the bedroom (.954 pt, β=.039, *P*=.043), were lifestyle factors associated with an increase in the stress response of the mind and body (F=37.405, *P*<.001, adjusted R2=.160). Sleep problems are themselves a result of lifestyle (sleep hygiene), and sleep disorders include factors that are difficult for the individual to improve on their own, so they were not included as explanatory variables. The regression coefficients for the lifestyle factors extracted as a result of this analysis were multiplied by the response results for each lifestyle and totaled to create a composite variable (lifestyle score related to mental health). This lifestyle score reflects the degree to which each lifestyle factor has an impact on changes in mental health over the next year.

3. Cross-lagged effects model

To examine the causal relationships among the lifestyle score, sleep, and psychosomatic stress response, we created a cross-delay effect model, and the results of examining the effect size are shown in Figures 2, 3, and 4. Those in Figures 2 and 3 are saturated models, and the model fit of the path analysis is saturated.

Figure 2 shows the relationships among lifestyle scores and psychosomatic stress responses. It was found that past lifestyle predicted future psychosomatic stress responses (standardized path coefficient = .075, $P < .001$), and this was greater than the degree to which past psychosomatic stress responses could be used to predict future lifestyle scores (.052, $P = .001$).

Figure 3 shows the relationships among sleep problems (PSQI) and psychosomatic stress responses. It was found that past sleep problems could be used to predict future psychosomatic stress responses (.154, *P*<.001), and that this was greater than the degree to which past psychosomatic stress responses could be used to predict future sleep problems (.076, *P*=.001).

Figure 4 shows the results of turning sleep and lifestyle into latent variables

as a single concept and showing their relationship with psychosomatic stress responses. The goodness-of-fit indices for this model were $\chi 2$=2.395 (P=.494), GFI=1.000, AGFI=.998, CFI=1.000, NFI=.999, and RMSEA=.000, indicating good fit. The results showed that while past lifestyle and sleep problems can be used to strongly predict future psychosomatic stress responses (.322, P<.001), past psychosomatic stress responses could not be used to significantly predict future lifestyle and sleep problems (-.024, P=.817). This model explained 46.0% of the variance in future psychosomatic stress responses.

The results of creating cross-lagged effect models for the lower scores of the psychosomatic stress response scores, namely, vigor, irritability, fatigue, anxiety, depression, and physical complaints, and calculating the path coefficients are shown in Table 4. Lifestyle and sleep problems could be used to significantly predict the following year's vigor (standardized path coefficient = .213), irritability (.174), fatigue (.300), anxiety (.255), depression (.253), and physical complaints (.227) (P<.001), the same results were generated when lifestyle and sleep were separated, and the degree of each showed a coefficient that was greater than the degree to which the mental health situation in the past could be used to predict lifestyle and sleep problems in the future.

IV. Discussion

This was the first study in the world to comprehensively and longitudinally examine the impact of lifestyle and sleep problems on the mental health of general office workers, while controlling for work conditions and other factors. Furthermore, the strength of this study was that it statistically estimated the effect size of the causal relationship. The results of analysis showed that several lifestyle and sleep problems significantly affected future mental health, and that these factors remained significant even after adjusting for various factors. In addition, time-series analysis showed that lifestyle and sleep problems are not a consequence of mental health problems, but rather a cause of such problems, and that the magnitude of the effect varies by factor.

In this study, the cross-lagged effects model using path analysis explained approximately 46.0% of the variability in psychosomatic stress responses in the following year, and these were predicted from the baseline of the psychosomatic stress responses in the previous year as well as lifestyle and sleep problems in the previous year. In particular, the effect of lifestyle in the previous year on psychosomatic stress responses in the following year was shown to have a

similar magnitude of effect to that of baseline psychosomatic stress responses on psychosomatic stress responses in the following year, indicating that lifestyle and sleep problems have a significant impact on mental health. Furthermore, it was also shown that lifestyle and sleep problems do not arise as a result of poor mental health in the previous year, and that lifestyle and sleep problems are independent factors.

The importance of primary prevention of mental health problems is clear, but the specific methodology for assessment is still being developed, and the results of this study suggest that improving lifestyle and sleep may play an important role. Furthermore, even if there are a wide range of lifestyle and sleep issues that need to be improved, the coefficients identified in this study can be used to prioritize addressing those items that are considered to have a greater impact on mental health problems by referring to the respective coefficients identified in this study, and this finding may be useful as guidance to improve mental health.

This study revealed the relationship between mental health and factors that had been shown to be associated with it by existing research, as well as factors that had received limited attention.

In terms of diet, this study also identified an association between vegetable consumption and mental health[27-29)32)36-38)] based on the frequency of consumption alone. This is consistent with the fact that a deficiency of folic acid, which is abundant in vegetables, can cause depression, and conversely, that the risk of developing depression can be reduced by continuous intake.[1)4)] There are considered to be many other mechanisms by which vegetables affect mental health, such as their effect on preventing high blood sugar[20)] and improving the intestinal environment. In addition, this study also showed the importance of not only the food one ingests but also the time of day at which it is consumed. Although skipping breakfast, which has been suggested to be related to depression,[39)] did not result in a significant difference in the multivariate analysis of this study, the regularity of meal times and eating dinner just before bed were associated with mental health problems. The results are consistent with the suggestion that regular mealtimes are important for physical and mental health from the perspective of regulating the body clock.[19)50)57)] Eating dinner immediately before bed was found to be slightly harmful. There is a lack of existing research on the appropriate timing of dinner, and it is only known that eating within 3 hours of going to bed is related to gastroesophageal reflux disease[14)] and

other adverse conditions. With regard to alcohol consumption, although cross-sectional studies identified an association between occasional drinking and low stress responses, multivariate analysis over time has shown conflicting results between cross-sectional and longitudinal studies, with both occasional and daily drinking worsening future mental health. When viewed cross-sectionally, this may mean that people with no mental health problems are able to secure more opportunities to drink alcohol or ingest a certain amount. Conversely, when viewed longitudinally, alcohol consumption had an undesirable effect on mental health. This is consistent with recent findings[16] showing that alcohol consumption is associated with health risks in a dose-dependent manner, and that the appropriate level of healthy consumption is zero. In addition, the frequency of drinking, rather than the amount, was found to be a significant factor, similar to the results of a cohort study[34] that found that high-frequency drinking (few days not drinking) was associated with future mortality. Alcohol can inhibit neurogenesis.[7] Frequent drinking creates a situation where the brain is constantly exposed to alcohol, and without a chance to recover, it can continue to cause organic damage to the brain; as a result, there is a possibility that mental health will be impaired.

In this study, we found only a very small effect size for exercise habits. There are also existing studies suggesting that the effect of exercise on mental health is limited,[18] and the fact that no significant difference was found in this study, which adjusted for multiple lifestyle factors, may reflect the low-level contribution of exercise. However, since we only asked whether subjects followed a regular exercise routine, this study was also limited. A cohort study of students[54] showed that exercise, smoking, and social rhythm[33] can be used to predict future mental health, and further investigation of exercise is needed in the future. Conversely, the results of this study showed that the amount of sedentary time, known to be associated with depression,[52] has an impact on mental health problems based on multivariate analysis. It is interesting that a significant difference was found on multivariate analysis, whereas no significant difference was noted on univariate analysis. It is possible that adjustment of the control factors revealed the true effect size. Thus, when physically demanding work becomes excessive, or when people are forced to commute long hours, sedentary behavior may decrease, but the stress

factor itself increases. This adjustment may have been important.

Items known as sleep and sleep hygiene were also identified as important factors related to mental health. Using curtains and blinds to block light, not exposing the bedroom to sunlight due to poor lighting, using electronic device displays just before or while in bed, and drinking caffeinated beverages at night have all been shown to be associated with sleep problems.[47] In this study, these factors were also significant regarding the psychosomatic stress response in the previous and following years, but when sleep and control factors were adjusted for, the significance of all factors except using electronic device displays just before bed or while in bed disappeared. This may be because they are considered to affect stress responses indirectly through sleep, and thus showed only a weak direct relationship. However, this does not negate the importance of these items. Since the issue of sleep itself was a factor that had a very significant impact on psychosomatic stress responses, it is considered that improving these items is important for those with sleep problems. Such problems can also be caused by work stress, but its overall impact is relatively limited, and previous cross-sectional studies showed that work stress and support from others can explain only about 14% of sleep problems.[46] The results of this study showed that sleep problems were twice as likely to be a cause of mental health problems rather than a result of them. Improving sleep is likely to be important in preventing future mental health problems. In addition, it is estimated that 20% of the Japanese population[31] and 45% of white-collar workers[10] have sleep problems, so there is much room to improve mental health problems by improving sleep problems.

One of the important results of this study was the fact that we were able to identify the lifestyle factors that increase or decrease the stress response over time, and the degree to which they do so. The factors finally extracted, in order of magnitude of their effect (regression coefficient) in this analysis, were daily alcohol consumption, irregular mealtimes, dinner within 1 hour of bedtime, not eating vegetables daily, occasional drinking, and not being exposed to morning sun in the bedroom. In addition, a dose-dependent adverse effect was observed in the length of time spent sitting and length of the commute. For example, commuting 120 minutes each way to work is estimated to have the same risk of worsening mental health as drinking alcohol every day. If an employee has many of these factors, it is possible to effectively reduce future mental health problems by prioritizing

improvements in items associated with large coefficients, while also taking into account the ease of improvement for the individual, as a type of behavioral therapy. In general, “diet, exercise, rest (sleep), alcohol consumption, smoking, and oral hygiene” are cited as health-related lifestyle factors. As will be discussed later, this study only examined "diet, exercise, rest (sleep), and alcohol consumption," and there are limitations to this, but the results of this section show that the impact of diet, rest, and alcohol consumption on fluctuations in mental health is significant.

This study also has multiple limitations. First, the survey was questionnaire-based, and the data obtained were not objectively measured. Diet, exercise, and sleep habits are all subjective, self-reported data, so the values are inherently imprecise. For this reason, the figures obtained through statistical analysis also remain imprecise. Second, this study used simple multiple regression analysis to estimate the impact. It analyzed a wide range of items as explanatory variables, and the structure is such that it is prone to statistical alpha errors, over-learning, and multicollinearity. In order to examine a wide range of lifestyle items simultaneously, a large number of samples were secured, and although the variance inflation factor (VIF) was within an acceptable range in the multiple regression analysis model that simultaneously input the same items for multiple years, there is a risk as a statistical method in principle. Third, there are lifestyle factors that have not been sufficiently confirmed this time, although existing research has suggested that they may affect mental health, and these have not been evaluated. For example, they included smoking, oral hygiene, participation in cultural activities, social connections, social rhythm, reading habits, hobbies, snacking, consumption of probiotic foods, consumption of unsaturated fatty acids including omega-3 fatty acids, consumption of iron and zinc, frequency of eating out, consumption of highly refined grains, consumption of snack foods, consumption of soft drinks, use of the Internet and social networking services, time spent playing games, and time spent watching television and other media. There are also issues with the validity of the questions. For example, in terms of exercise, the survey only evaluated whether a person had a regular exercise habit. In addition, there were some areas where the reliability and accuracy of the survey were lacking, such as the evaluation of eating habits, which was conducted using questions created specifically for this study. It is hoped that in the future, surveys that include these aspects will

be conducted again. Finally, although this study was able to statistically estimate a causal relationship, this is only an estimate, and it does not substitute for actual intervention studies. Therefore, there is a need to conduct randomized controlled trials that actually provide guidance focusing on lifestyle and sleep, and to more accurately assess the impact of lifestyle and sleep improvements on mental health.

Conclusion

Lifestyle and sleep problems were significantly correlated with the increase or decrease in psychosomatic stress responses in the year and following year. These were significant even after adjusting for work stressors and social support, suggesting that lifestyle and sleep problems affect office workers' mental health independently of work-related factors. The longitudinal survey and its analyses showed that past stress responses could not be used to predict current lifestyle and sleep problems, but that past lifestyle and sleep problems could be used to predict current stress responses. Lifestyle and good sleep, which are related to as mental health, act as assets and resilience that nurture good psychological states in the future, and improving them may be one of the measures for mental health care and primary prevention from a different perspective to psychotherapy and drug therapy.

Conflict of Interest

The Tokyo Medical University Educational Corporation has applied for a patent (Patent Application: 2021-83372) for a system that can be used to predict mental health conditions and trends based on multiple lifestyle and sleep conditions, and also prioritizes and proposes improvement measures, based on this research and the surveys conducted following it. Shimura has received lecture fees from Sumitomo Pharmaceuticals Co., Ltd., and Eisai Co., Ltd., which were unrelated to this research, and is also an officer of Kodomo Mirai Co. Ishibashi receives remuneration as an occupational physician from Kodomo Mirai Co., Ltd., without any connection to this research. Nishikawa serves as an officer of the Tokyo Sakurajuji Medical Corporation, which was unrelated to this research. Inoue received honoraria for lectures unrelated to this study from Mochida Pharmaceutical Co., Ltd., Takeda Pharmaceutical Company Limited, Eli Lilly Japan K.K., Janssen Pharmaceutical K.K., MSD K.K., Taisho Pharmaceutical Co., Ltd., Yoshitomi Pharmaceutical Co., Ltd., Ono Pharmaceutical Co., Ltd., Otsuka Pharmaceutical Co., Ltd., Sumitomo

Pharma Co., Ltd., Mitsubishi Tanabe Pharma Corporation, Kyowa Pharmaceutical Industry Co., Ltd., Pfizer Japan Inc., Shionogi & Co., Ltd., Tsumura & Co., Novartis Pharma K.K., Eisai Co., Ltd., Daiichi Sankyo Healthcare Co., Ltd., and Meiji Seika Pharma Co., Ltd., and serves on the advisory board of Pfizer Japan Inc., Novartis Pharma K.K. and Mitsubishi Tanabe Pharma Corporation, which were also unrelated to this study. The other authors have no conflicts of interest to declare.

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Figure 1: Schematic diagram of the cross-lagged effect model

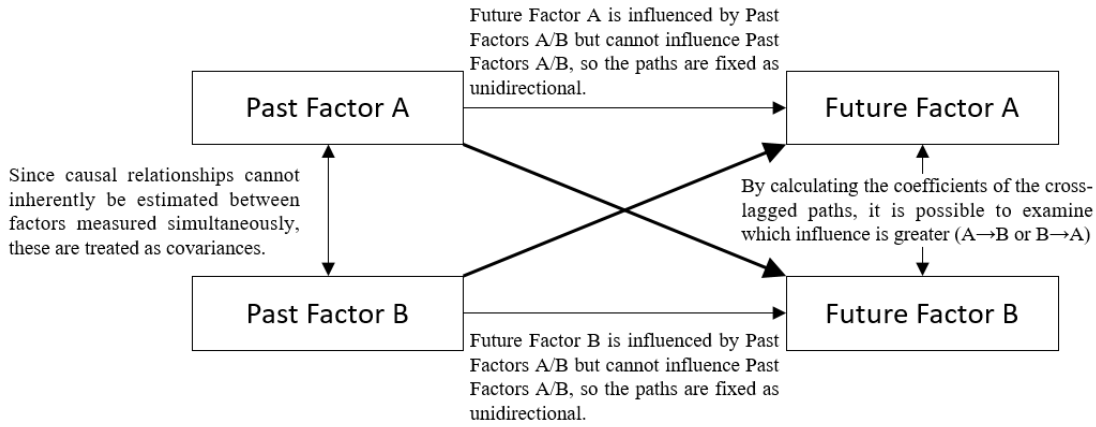


Figure 1: Schematic diagram of the cross-lagged effect model

Table 1: Basic statistics and average scores for psychosomatic stress responces

Items	Previous year (T0)					Difference (next year T1 - previous year T0)		
	N (%) / Mean (SD)		Mean score for psychosomatic stress responces (SD)		Statistical values for comparison (t / r /F)	Mean score for psychosomatic stress responces (SD)		Statistical values for comparison (t / r /F)
Total	2289	(100%)	56.2	(13.7)	-	1.64	(11.7)	-
Control factors: previous year (T0)								
Sex: female	781	(34.1%)	57.8	(13.6)	t=-4.16***	2.24	(12.4)	t=-1.80
Age (years)	37.5	(9.2)			r=-.050*			r=-.048*
Living alone	778	(34%)	56.6	(13.4)	t=0.96	2.32	(11.5)	t=2.01*
Marriage: single	1186	(51.8%)	56.7	(13.3)	t=1.90	2.11	(11.4)	t=2.01*
Change in the word: yes	1241	(54.2%)	57.5	(14.5)	t=5.05***	1.46	(12.9)	t=-0.82
Change in life: yes	806	(35.2%)	57.7	(14.5)	t=4.04***	1.38	(13.1)	t=-0.78
Overtime work (hours / month)	24.9	(27.0)			r=.098***			r=-.062**
Job stressors (/pt)	38.9	(6.3)			r=.527***			r=-.186***
Social support (/pt)	19.7	(5.3)			r=.396***			r=-.111***
Psychosomatic stress responces (/pt)	56.2	(13.7)			r=1			r=-.375***
Lifestyle factors: previous year (T0)								
Commuting time (minutes / oneway)	55.4	(24.7)			r=.044*			r=.002
Irregular mealtimes	907	(39.6%)	60.6	(14.1)	t=13.14***	0.54	(12.1)	t=-3.66***
Skipping breakfast	925	(40.4%)	58.4	(14.3)	t=6.50***	1.38	(12.4)	t=-0.90
Dinner within 1 hour before bed	249	(10.9%)	60.8	(15.0)	t=5.70***	1.58	(12.3)	t=-0.09
Skipping dinner	36	(1.6%)	65.7	(19.0)	t=4.23***	-5.92	(18.3)	t=-3.93***
Not eating vegetables every day	821	(35.9%)	59.4	(14.1)	t=8.61***	1.26	(11.6)	t=-.116
Frequency of drink: every day	335	(14.6%)	56.8	(13.7)	F=2.82*	1.50	(11.1)	F=3.10*
Frequency of drink: occasionally	1709	(74.7%)	55.7	(13.1)		1.94	(11.3)	
Alcohol consuming: 1-13 drinks / weak	1527	(66.7%)	55.5	(13.0)	F=4.02**	2.03	(11.1)	F=1.77
Alcohol consuming: 14+ drinks / weak	199	(8.7%)	57.5	(13.3)		1.08	(12.0)	
No exercise habit	1235	(54.0%)	56.8	(13.6)	t=2.26*	1.51	(11.7)	t=-0.60
Sedentaly behavior (%time / day)	85.1	(18.9)			r=.014			r=.043*
No morninng sunlight exposure in the bedroom	1469	(64.2%)	57.3	(13.7)	t=5.43***	1.63	(11.6)	t=-0.06
Using electronic displays before bed	1047	(45.7%)	55.9	(13.0)	F=33.26***	1.60	(11.2)	F=3.33***
Using electronic displays in bed	697	(30.4%)	59.1	(14.0)		0.93	(12.2)	
Caffeine intake at night: occasionally	1219	(53.3%)	55.2	(13.4)	F=11.52***	1.85	(11.4)	F=0.52
Caffeine intake at night: every day	927	(40.5%)	57.8	(14.0)		1.34	(12.0)	
Sleep: previous year (T0)								
Sleep disturbance (PSQI)	6.3	(2.7)			r=.569***			r=-.087**
Existence of sleep disturbance (PSQI >= 6)	1338	(58.5%)	61.3	(13.2)	t=23.97***	1.06	(12.8)	t=-2.85**

T: unpaird t-test with the control category, r: Pearson's correlation coefficient, F: ANOVA includes the control category.
*:p<.05, **:p<.01, ***:p<.001

Table 1: Basic statistics and average scores for psychosomatic stress responses

Table 2: Multiple regression analysis of the effect of lifestyle and sleep on psychosomatic stress response in the next year (T1)

Items	Model 1				Model 2				Model 3				Model 4			
	Regression coefficient	Standardized coefficient	VIF	p-value	Regression coefficient	Standardized coefficient	VIF	p-value	Regression coefficient	Standardized coefficient	VIF	p-value	Regression coefficient	Standardized coefficient	VIF	p-value
Control factors: next year (T1)																
Sex: female	4.012	.133	1.142	<.001					3.841	.128	1.184	<.001	3.797	.126	1.098	<.001
Age (years)	-0.117	-.075	1.364	<.001					-0.122	-.078	1.483	<.001	-0.108	-.069	1.376	<.001
Living alone	0.515	.017	1.935	.446					1.367	.045	4.412	.177				
Marriage: single	-1.039	-.036	2.017	.108					-0.361	-.013	4.769	.714				
Change in the word: yes	2.185	.076	1.092	<.001					1.979	.069	1.145	<.001	2.051	.072	1.097	<.001
Change in life: yes	2.262	.075	1.053	<.001					2.145	.071	1.117	<.001	2.162	.072	1.079	<.001
Overtime work (hours / month)	-0.015	-.025	1.169	.150					-0.003	-.005	1.352	.794				
Job stressors (/pt)	0.894	.418	1.399	<.001					0.868	.406	1.908	<.001	0.893	.418	1.342	<.001
Social support (/pt)	0.526	.197	1.303	<.001					0.423	.158	1.873	<.001	0.418	.156	1.793	<.001
Lifestyle factors: next year (T1)																
Commuting time (minutes / oneway)	0.030	.052	1.167	.002					0.027	.047	2.724	.072	0.025	.045	1.088	.007
Irregular mealtimes	3.238	.095	1.455	<.001					2.614	.077	1.863	<.001	2.784	.082	1.680	<.001
Skipping breakfast	0.312	.011	1.226	.545					-0.138	-.005	2.052	.835				
Dinner within 1 hour before bed	1.023	.023	1.094	.164					0.951	.022	1.240	.221				
Skipping dinner	2.739	.022	1.027	.177					3.007	.024	1.079	.145				
Not eating vegetables every day	3.348	.094	1.250	<.001					2.862	.081	1.637	<.001	3.288	.093	1.202	<.001
Frequency of drink: every day	0.346	.007	2.881	.788					0.379	.008	4.181	.805				
Frequency of drink: occasionally	-1.397	-.043	3.149	.128					-1.041	-.032	4.190	.322	-1.281	-.039	1.027	.014
Alcohol consuming: 1-13 drinks / weak	0.539	.018	2.662	.490					1.079	.036	3.341	.214				
Alcohol consuming: 14+ drinks / weak	0.987	.019	2.155	.417					1.070	.021	2.702	.429				
No exercise habit	0.121	.004	1.068	.797					0.142	.005	1.441	.794				
Sedentaly behavior (%time / day)	4.232	.056	1.065	.001					2.151	.028	1.619	.158				
No mominng sunlight exposure in the bedroom	1.815	.061	1.027	<.001					1.289	.043	1.341	.018	1.667	.056	1.035	<.001
Using electronic displays before bed	1.596	.056	1.640	.006					1.323	.046	1.877	.033	1.377	.048	1.655	.018
Using electronic displays in bed	2.272	.072	1.766	.001					1.161	.037	2.299	.128	1.214	.038	2.114	.096
Caffeine intake at night: occasionally	0.401	.013	1.597	.510					0.402	.013	1.692	.518				
Caffeine intake at night: every day	1.786	.062	1.609	.002					1.609	.056	1.894	.011	1.423	.049	1.024	.002
Control factors: previous year (T0)																
Sex: female					3.979	0.132	1.142	<.001					-			
Age (years)					-0.154	-0.099	1.417	<.001					-			
Living alone					0.513	.017	1.950	.507	-1.044	-.035	4.507	.303				
Marriage: single					-0.337	-.012	2.056	.654	-0.659	-.023	4.768	.505	-0.904	-.032	1.269	.075
Change in the word: yes					0.902	.032	1.079	.099	0.141	.005	1.136	.771				
Change in life: yes					1.632	.055	1.079	.004	1.115	.037	1.136	.027	1.183	.040	1.099	.017
Overtime work (hours / month)					-0.016	-.031	1.120	.112	-0.018	-.034	1.289	.056	-0.016	-.031	1.092	.065
Job stressors (/pt)					0.583	.260	1.375	<.001	0.053	.024	1.867	.274				
Social support (/pt)					0.483	.179	1.280	<.001	0.173	.064	1.865	.003	0.201	.075	1.617	<.001
Lifestyle factors: previous year (T0)																
Commuting time (minutes / oneway)					0.033	.057	1.186	.005	-0.001	-.001	2.709	.962				
Irregular mealtimes					3.354	.098	1.452	<.001	1.208	.035	1.862	.101	1.573	.046	1.595	.021
Skipping breakfast					0.640	.022	1.223	.279	0.438	.015	2.036	.505				
Dinner within 1 hour before bed					1.782	.039	1.094	.043	0.190	.004	1.250	.815				
Skipping dinner					-2.600	-.023	1.049	.228	-1.627	-.014	1.123	.398				
Not eating vegetables every day					2.308	.065	1.244	.001	0.524	.015	1.616	.460				
Frequency of drink: every day					1.546	.034	2.892	.284	0.281	.006	4.144	.850				
Frequency of drink: occasionally					0.420	.013	3.176	.696	0.001	.000	4.162	.999				
Alcohol consuming: 1-13 drinks / weak					-0.228	-.008	2.570	.798	-1.056	-.035	3.312	.226				
Alcohol consuming: 14+ drinks / weak					0.310	.006	2.101	.818	-0.107	-.002	2.707	.936				
No exercise habit					0.469	.016	1.050	.384	0.145	.005	1.410	.787				
Sedentaly behavior (%time / day)					4.165	.055	1.073	.004	3.551	.047	1.608	.020	4.622	.061	1.066	<.001
No mominng sunlight exposure in the bedroom					1.828	.061	1.030	.001	0.759	.026	1.331	.162				
Using electronic displays before bed					0.604	.021	1.671	.375	-0.186	-.007	1.891	.765				
Using electronic displays in bed					1.919	.062	1.822	.013	1.633	.053	2.372	.031	1.828	.059	1.370	.001
Caffeine intake at night: occasionally					0.389	.013	1.598	.578	-0.419	-.014	1.701	.500				
Caffeine intake at night: every day					0.966	.033	1.638	.158	-0.023	-.001	1.935	.972				
	F=64.092 (p<.001) Adjusted R^2=0.418				F=26.641 (p<.001) Adjusted R^2=0.226				F=34.870 (p<.001) Adjusted R^2=0.425				F=82.449 (p<.001) Adjusted R^2=0.428			

Model 1: A model analyzing the relationship between lifestyle and control factors for the next year and stress responses for the next year.

Model 2: A model analyzing the impact of lifestyle and control factors from the previous year on stress responses for the next year.

Model 3: A model analyzing the impact of both next-year and previous-year lifestyle and control factors on stress responses for the next year.

Model 4: A model based on Model 3, with variable selection performed using a stepwise reduction method (removal criterion: $p < .01$).

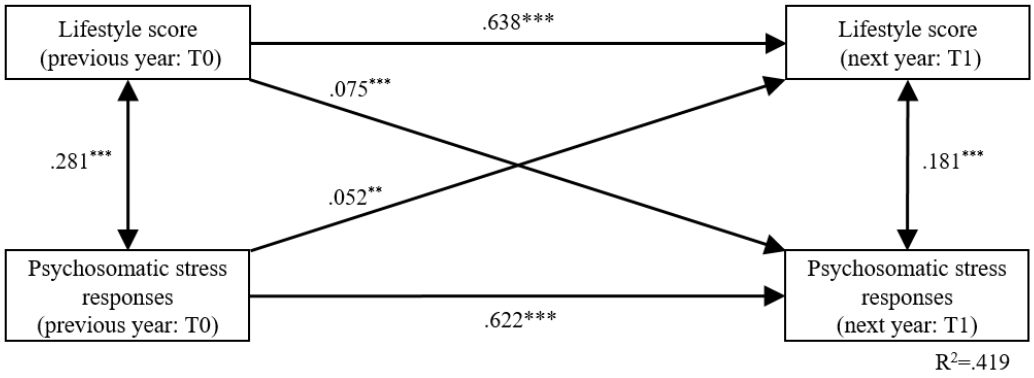
Table 2: Multiple regression analysis of the effects of lifestyle and sleep on physical and mental stress responses in the following year (T1)

Table 3: Multiple regression analysis of the impact of lifestyle in the previous year on psychosomatic stress responses

	Using all variables (forced entry)				Stepwise variable reduction method			
	Regression coefficient	Standardized coefficient	VIF	p-value	Regression coefficient	Standardized coefficient	VIF	p-value
Total								
Control factors: previous year (T0)	2.000	.081	1.163	<.001	1.998	.081	1.066	<.001
Sex: female	-0.088	-.069	1.423	.003	-0.088	-.069	1.177	<.001
Age (years)	0.876	.036	1.934	.184				
Living alone	-0.073	-.003	2.056	.909				
Marriage: single	0.453	.019	1.081	.331				
Change in the word: yes	0.466	.019	1.084	.340				
Change in life: yes	-0.013	-.030	1.101	.143				
Overtime work (hours / month)	0.045	.025	1.631	.316				
Job stressors (/pt)	0.115	.052	1.670	.020	0.128	.058	1.277	.007
Social support (/pt)	-0.375	-.439	1.367	<.001	-0.360	-.423	1.270	<.001
Lifestyle factors: previous year (T0)								
Commuting time (minutes / oneway)	0.020	.042	1.184	.042	0.016	.034	1.152	.084
Irregular mealtimes	0.599	.021	1.008	.358	1.670	.049	1.055	.007
Skipping breakfast	0.385	.016	1.125	.445				
Dinner within 1 hour before bed	1.324	.035	1.075	.078	1.410	.038	1.026	.056
Skipping dinner	-5.278	-.056	1.042	.004				
Not eating vegetables every day	0.986	.034	1.169	.111	1.369	.047	1.111	.019
Frequency of drink: every day	1.525	.040	2.893	.215	1.747	.046	1.599	.056
Frequency of drink: occasionally	0.928	.035	3.178	.311	1.079	.040	1.566	.093
Alcohol consuming: 1-13 drinks / weak	0.254	.010	2.570	.739				
Alcohol consuming: 14+ drinks / weak	0.393	.009	2.098	.733				
No exercise habit	0.238	.010	1.037	.604				
Sedentaly behavior (%time / day)	2.861	.046	1.064	.020	2.382	.038	1.025	.048
No mominng sunlight exposure in the bedroom	0.939	.039	1.025	.048	0.954	.039	1.021	.043
Using electronic displays before bed	-0.566	-.024	1.676	.330				
Using electronic displays in bed	-0.743	-.029	1.851	.262				
Caffeine intake at night: occasionally	0.154	.006	1.597	.796				
Caffeine intake at night: every day	0.526	.022	1.639	.367				
	F=17.060 (p<.001) Adjusted R^2=0.159				F=37.405 (p<.001) Adjusted R^2=0.160			

Table 3: Multiple regression analysis of the impact of lifestyle in the previous year on fluctuations in physical and mental stress responses

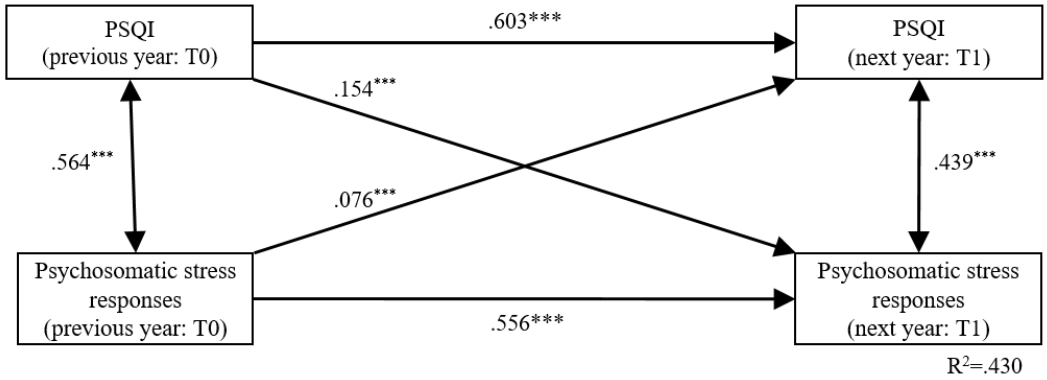
Figure 2: Longitudinal analysis of lifestyle and psychosomatic stress responses using a cross-lagged model



The numbers in the figure represent standardized path coefficients. **:p<.01, ***:p<.001

Figure 2: Temporal analysis of lifestyle and psychosomatic stress responses using the cross-lagged model

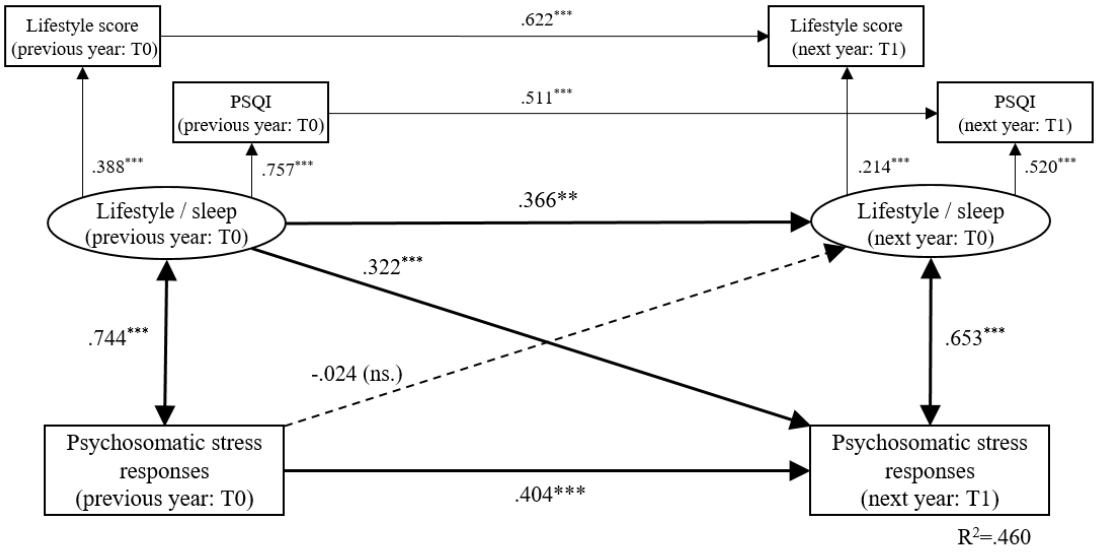
Figure 3: Longitudinal analysis of sleep and psychosomatic stress responses using a cross-lagged model



The numbers in the figure represent standardized path coefficients. ***:p<.001

Figure 3: Temporal analysis of sleep and psychosomatic stress responses using the cross-lagged model

Figure 4: Longitudinal analysis of lifestyle / sleep and psychosomatic stress responses using a cross-lagged model



The numbers in the figure represent standardized path coefficients. **:p<.01, ***:p<.001
Model fit indices: GFI=1.000、AGFI=0.998、CFI=1.000、NFI=0.999、RMSEA=0.000

Figure 4: Temporal analysis of lifestyle, sleep, and psychosomatic stress responses using the cross-lagged effects model

Table 4: Effect sizes of the causal relationships between variables estimated by the cross-lagged model

	Psychosomatic stress response	Mental health subitems					
		Vigor	Irritability	Fatigue	Anxiety	Depression	Physical complaints
Lifestyle-only model							
Correlation between lifestyle and mental health items in the previous year	.281 (p<.001)	.203 (p<.001)	.164 (p<.001)	.224 (p<.001)	.190 (p<.001)	.213 (p<.001)	.263 (p<.001)
Correlation between lifestyle habits and mental health items in the next year	.181 (p<.001)	.117 (p<.001)	.134 (p<.001)	.174 (p<.001)	.124 (p<.001)	.124 (p<.001)	.164 (p<.001)
Impact of lifestyle habits in the previous year on mental health items in the next year	.075 (p<.001)	.086 (p<.001)	.077 (p<.001)	.086 (p<.001)	.099 (p<.001)	.080 (p<.001)	.061 (p<.001)
Impact of mental health items in the previous year on lifestyle habits in the next year	.052 (p=.001)	.034 (p=.035)	.028 (p=.084)	.051 (p=.002)	.035 (p=.031)	.043 (p=.009)	.057 (p<.001)
Sleep-only model							
Correlation between sleep disturbance and mental health items in the previous year	.564 (p<.001)	.346 (p<.001)	.308 (p<.001)	.403 (p<.001)	.392 (p<.001)	.472 (p<.001)	.528 (p<.001)
Correlation between sleep disturbance and mental health items in the next year	.439 (p<.001)	.239 (p<.001)	.250 (p<.001)	.313 (p<.001)	.270 (p<.001)	.371 (p<.001)	.378 (p<.001)
Impact of sleep disturbance in the previous year on mental health items in the next year	.154 (p<.001)	.122 (p<.001)	.108 (p<.001)	.182 (p<.001)	.160 (p<.001)	.163 (p<.001)	.124 (p<.001)
Impact of mental health items in the previous year on sleep disturbance in the next year	.076 (p<.001)	.053 (p<.001)	.034 (p=.043)	.050 (p=.004)	.049 (p=.005)	.038 (p=.037)	.074 (p<.001)
Lifestyle and sleep combined model							
Correlation between lifestyle-sleep and mental health items in the previous year	.749 (p<.001)	.493 (p<.001)	.423 (p<.001)	.553 (p<.001)	.516 (p<.001)	.593 (p<.001)	.688 (p<.001)
Correlation between lifestyle-sleep and mental health items in the next year	.659 (p<.001)	.351 (p<.001)	.396 (p<.001)	.509 (p<.001)	.384 (p<.001)	.464 (p<.001)	.563 (p<.001)
Impact of lifestyle-sleep in the previous year on mental health items in the next year	.322 (p<.001)	.213 (p<.001)	.174 (p<.001)	.300 (p<.001)	.255 (p<.001)	.253 (p<.001)	.227 (p<.001)
Impact of mental health items in the previous year on lifestyle-sleep in the next year	-.021 (p=.817)	.002 (p=.964)	.-013 (p=.763)	.000 (p=.994)	-.007 (p=.893)	-.058 (p=.273)	-.003 (p=.962)
Model fit	Good Fit	Good Fit	Good Fit	Good Fit	Good Fit	Good Fit	Good Fit

The numerical values represent the standardized path coefficients or correlation coefficients in the cross-lagged model.

Table 4: Effect sizes of the causal relationships between variables estimated by the cross-lagged model