A tryptophan-rich breakfast and exposure to light with low color temperature at night improve sleep and salivary melatonin level in Japanese students

Kai Wada1, Shota Yata2, Osami Akimitsu1, Milada Krejci3, Teruki Noji2, Miyo Nakade4, Hitomi Takeuchi1 and Tetsuo Harada1*

Abstract

Background: Epidemiological studies in Japan have documented an association between morning type and a tryptophan-rich breakfast followed by exposure to sunlight in children. The association may be mediated by enhanced melatonin synthesis, which facilitates sleep at night. However, melatonin is inhibited by artificial light levels with high color-temperature common in Japanese homes at night. In this study, we investigated whether a combination of tryptophan-rich breakfast and light with low color-temperature at night could enhance melatonin secretion and encourage earlier sleep times.

Methods: The intervention included having breakfast with protein- and vitamin B6 - rich foods and exposure to sunlight after breakfast plus exposure to incandescent light (low temperature light) at night (October-November, 2010). The participants were 94 members of a university soccer club, who were divided into 3 groups for the intervention (G1: no intervention; G2: asked to have protein-rich foods such as fermented soybeans and vitamin B6-rich foods such as bananas at breakfast and sunlight exposure after breakfast; G3: the same contents as G2 and incandescent light exposure at night). Salivary melatonin was measured around 11:00 p.m. on the day before the beginning, a mid-point and on the day before the last day of the 1 month intervention.

Results: In G3, there was a significantly positive correlation between total hours the participants spent under incandescent light at night and the frequency of feeling sleepy during the last week (p = 0.034). The salivary melatonin concentration of G3 was significantly higher than that of G1 and G2 in combined salivary samplings at the mid-point and on the day just before the last day of the 1 month intervention (p = 0.018), whereas no such significant differences were shown on the day just before the start of the intervention (p = 0.63).

Conclusion: The combined intervention on breakfast, morning sunlight and evening-lighting seems to be effective for students including athletes to keep higher melatonin secretion at night which seems to induce easy onset of the night sleep and higher quality of sleep.

Keywords: Salivary melatonin, Tryptophan, Protein rich breakfast, Sunlight exposure, Lighting with low color temperature

* Correspondence: haratets@kochi-u.ac.jp
1Laboratory of Environmental Physiology, Graduate School of Integrated Arts and Sciences, Kochi University, Kochi, Japan
Full list of author information is available at the end of the article

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Background

Tryptophan is an essential amino acid that can be absorbed exclusively from meals in humans. It is metabolized via 5-hydroxytryptamine (serotonin) to melatonin by a series of 4 enzymes in the pineal body [1,2]. Serotonin is known as a precursor to melatonin. A lack of serotonin causes depression, panic disorder, obsessive-compulsive disorder, sleep disorders and eating disorders [3] and induces aggression, anxiety/aggression-driven depression, impulsive behavior and suicidal attempts [4,5]. Serotonin thus has a strong relationship with mental health. In the past two decades, serotonin reuptake inhibitors (SSRIs) have come to be widely used for the treatment of affective disorders including depression, although [6] there are controversies whether SSRIs are effective or not for the treatment of depression in children and adolescents because of the shortage of coincident scientific evidence of SSRIs for young humans.

Exposure to sunlight in the daytime appears to trigger synthesis of serotonin in the pineal body [7]. This action is hypothesized to occur mainly in the morning hours, because the amount of tryptophan consumed with supper has neither significant effects on Morningness-Eveningness (M-E) scores nor an effect on sleep habits, as shown by another study on young Japanese children performed in 2005 [8].

Melatonin is synthesized in the pineal body of the hypothalamic area and secreted at night. Melatonin level in the serum can be well and positively correlated with that in the saliva [9-12]. Secretion of melatonin exhibits circadian rhythms and is suppressed by bright light at night [13,14]. Even room lights such as fluorescent lamps can attenuate melatonin excretion duration at night [15]. Evening lighting conditions are also said to affect circadian rhythms [16,17] and mental health in mice [18]. Tryptophan intake at breakfast is effective for the onset and offset of sleep in young children [19]. Moreover, questionnaire surveys showed that young children exposed to sunlight for more than 30 minutes after having sources of protein at breakfast are more morning-typed than those exposed for less than 30 minutes [20], and that the more young children take in vitamin B6 at breakfast, the more they exhibit morning typology [21].

Although these findings imply that morning tryptophan and vitamin B6 intake and following exposure to sunlight would promote synthesis of serotonin in the daytime and further to melatonin at night, it is difficult to test the hypothesis only with questionnaire studies. Moreover, this melatonin synthesis might be inhibited by exposure to short-wave (blue) light including light emitted from fluorescent lamps. This hypothesis cannot be tested by questionnaire work and would require an intervention field experiment. An intervention field experiment for was thus performed on university students to test the hypotheses.

Methods

The intervention program was administered to 94 subjects (male, 19-22 years old, average age: 20.33) belonging to a university soccer club. 63 subjects answered to the integrated questionnaire before the intervention period. They were divided into three groups (G1, n = 20: no intervention; G2, n = 22: asked to have protein-rich foods such as fermented soybeans and vitamin B6-rich foods such as bananas at breakfast and sunlight exposure after breakfast; G3, n = 21: the same contents as G2 and incandescent light exposure at night). This university football club includes only men. All the members used fluorescent lamps (white light) for the lighting at night. To estimate the effects of the one month interventions, integrated questionnaires were administered to all participants three times: before the start of the intervention period, immediately after the end of the intervention period, and one month after the end of the intervention period (See note on Figure 1). The questionnaires which were administered before the intervention and 1 month after the intervention consisted of the diurnal-type scale constructed by Torsvall and Åkerstedt [22], questions on sleep habits and meal habits [23], an irritation index, the General Health Questionnaire (GHQ), the Sense of Coherence (SOC) questionnaire, and FFQ (Food Frequency Questionnaire). The questionnaire just after the intervention period of 1 month consisted of self-assessment questions asking how many days during the month-long intervention period they followed the recommendations for breakfast content (the first point), sunlight exposure after breakfast (the second point) and the use of light bulbs that emit lower color temperature light at night (the third point). We made nine groups initially based on the scores of the diurnal-type scale (three groups: morning-type, middle-type, evening-type) and FFQ three groups: good, mid, bad). After that we divided participants into three groups for each of the nine groups with random number list arbitrarily. There were no significant differences among the body height, body mass and age of the three groups.

All participants were asked to keep a sleep diary throughout the 30 days of the intervention period, which was October- November in 2010. The sleep diary involved the question, “How was the depth of your last night’s sleep?” to which participants answered every morning. The choices for answer were “deep”, “relatively deep”, “relatively shallow” and “shallow”.

Incandescent light bulbs were distributed one by one to the participants in the G3 group, and these participants were asked to install the light bulb in the room in which they slept at night. The G1 and G2 members were
asked to switch fluorescent lamps on and the G3 ones were asked to switch incandescent light bulbs on, instead, when they got back to their residences after sunset. After the incandescent light was set, illumination intensity was measured (Table 1). Participants of G2 and G3 were asked to report their breakfast contents, and G3 were also asked to answer the duration of their time spent under incandescent light each day. 63 of 94 (67%) participants answered the first questionnaire and 51 of 63 (81%) kept sleep diaries for 1 month.

The implementation score was calculated from the sum of days that had “high protein content breakfast” and “exposure to >30 min-exposure to sunlight”. For night exposure to low temperature light, the implemental score was defined as the mean hours (per night for 30 days) when participants were exposed to the low temperature light.

Table 1 Illumination value (Lux) of all subjects in the third group (G3)

| Standing under the light* | Sitting as usual* |
|--------------------------|------------------|
| **Fluorescent** | **Incandescent** | **Fluorescent** | **Incandescent** |
| Max | Min | Ave | Max | Min | Ave | Max | Min | Ave |
| A | 579 | 571 | 574 | 76 | 74 | 74 | 173 | 158 | 166 |
| B | 845 | 601 | 774 | 42 | 38 | 40 | 143 | 122 | 130 |
| C | 186 | 160 | 170 | 18 | 18 | 18 | 34 | 32 | 33 |
| D | 358 | 344 | 352 | 21 | 15 | 18 | 108 | 100 | 105 |
| E | 1120 | 1050 | 1019 | 32 | 28 | 30 | 89 | 86 | 87 |
| F | 1042 | 1013 | 1025 | 42 | 38 | 40 | 272 | 246 | 257 |
| G | 644 | 572 | 604 | 52 | 50 | 51 | 168 | 103 | 144 |
| H | 3997 | 2479 | 2942 | 70 | 61 | 63 | 284 | 277 | 281 |
| I | 1200 | 1002 | 1106 | 24 | 23 | 23 | 205 | 122 | 163 |
| J | 1155 | 1106 | 1132 | 41 | 41 | 41 | 196 | 184 | 189 |
| K | 657 | 651 | 654 | 72 | 70 | 70 | 65 | 64 | 64 |
| L | 173 | 137 | 148 | 26 | 8 | 19 | 134 | 128 | 130 |
| M | 1092 | 908 | 1025 | 377 | 360 | 370 | 597 | 263 | 341 |
| N | 64 | 59 | 61 | 1 | 1 | 1 | 131 | 114 | 131 |
| O | 505 | 433 | 465 | 160 | 133 | 150 | 231 | 145 | 86 |
| P | 1307 | 1193 | 1264 | 438 | 431 | 434 | 42 | 41 | 41 |
| Q | 591 | 542 | 572 | 140 | 129 | 136 | 149 | 146 | 147 |
| R | 1376 | 1078 | 1213 | 544 | 483 | 511 | 66 | 49 | 52 |
| S | 1 | 1 | 0 | 346 | 254 | 316 | 1 | 1 | 1 |
| T | 31 | 30 | 30 | 207 | 193 | 202 | 65 | 58 | 61 |

*The surface of illumination meter sensor was put vertically just in front of eyes of participants who are standing* or sitting* and illumination value was measured.

Figure 1 The schedules of the interventions.
emitted from the incandescent bulb. After the intervention period for 30 days, the participants were asked to mark the scores on “To what extent do you satisfy on your own carrying out each of the two (G2) or three (G3) contents of intervention as a whole for 30 days, marking as 0-100 points as ‘satisfaction score’?” (Table 2).

The salivary melatonin was measured of 10 subjects which were randomly selected from each group because of financial limitation for the chemical analysis (30 participants in total) three times: the day before the start of intervention, at the mid-point (two weeks past in the intervention) and the day before the last day of the intervention. Participants were asked to extract their own saliva at around 23:00 and keep it in a freezer. They turned off the lights when they went to bed (ranging from 23:00 to 2:00).

The saliva samples were collected around 23:00 with cylindrical cotton (1 cm diameter, 3 cm long) which was put under the tongue for 3 min. The saliva samples were kept frozen at −25°C until analysis for 1 or 2 weeks. After centrifugation (1000 × g for 5 min), melatonin concentrations in the saliva samples were determined using an ELISA kit (Direct Saliva Melatonin ELISA, Bulmann, Switzerland).

For the statistical analysis, the “implementation rate” was defined as how many days participants had a protein-rich food (1 point) and Vitamin B6-rich food (1 point) at breakfast and, further, exposed to sunlight for more than 30 min after breakfast (1 point). Participants reported how many minutes they were exposed to low-color temperature lights during the 30 intervention days. The 30-day-long intervention period was divided into 3 parts (FWP: First week period, MP: Medium period of 16 days, LWP: Last week period). The “high implementation group” was defined as 50% participants who marked higher implementation rate in both breakfast contents and exposure to sunlight after breakfast (G2 and G3) and also were exposed to longer hours when they were exposed to the low temperature lights each

**Table 2 Estimates of the extent to which subjects in groups G2 and G3 carried out the intervention**

| Question: On a scale of 0 to 100, how would you estimate your confidence in your response? The question is “To what extent did you carry out this intervention program during this one month intervention period? |
| 1. Estimate for the whole protocol. (G2, G3) | score /100 |
| 2. Estimate for "taking protein-rich and Vitamin B6-rich foods at breakfast". (G2, G3) | score /100 |
| 3. Estimate for "exposure to sunlight after the breakfast". (G2, G3) | score /100 |
| 4. Estimate for "exposure to low color temperature light emitted from incandescent bulbs at night". (G3) | score /100 |

**Figure 2** Positive correlation between hours when subjects were exposed to incandescent light at night and the index of feeling of sleeping well in Last Week Period. Upper and lower lines of linear regression line show 95% confidence estimate.
night (G3). The other 50% participants group was defined as “the low implementation group”.

The software used for statistical analysis was SPSS 12.0 J for Windows (SPSS Inc., Chicago, IL, USA). $\chi^2$-test was used for categorized variables and Mann-Whitney U-tests was used for ranked variables. Pearson’s correlation analysis was performed to test the relationship between two numerical variables.

Before the beginning of the study, participants received a full explanation with the code of the guideline for a study targeting humans [24], including that the results of the study would be used only for academic

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**Figure 3** Comparison of salivary melatonin concentration among the three groups. Group 1: no intervention; Group 2: Recommendation of high protein breakfast and exposure to sunlight; Group 3: Same as Group 2 plus the recommendation of exposure to low color temperature light emitted from an incandescent light bulb. A. Melatonin level in the saliva collected on the day just before the intervention (Kruskal Wallis test: $\chi^2$-value = 0.92, df = 2, p = 0.63); B. Melatonin in the saliva collected at the mid-point and on the day before the last day of the intervention (Bonferroni multiple comparison test: G1 versus G3, p = 0.018; G2 versus G3, p = 0.011).
purposes, and all participants completely agreed to participate in the study.

Results
Sleep diary data and salivary melatonin concentration during the 30 days of the intervention
There was significant positive correlation between hours spent under incandescent light at night and the feeling of sleeping well in Last Week Period (LWP) (Pearson’s correlation test: $r^2 = 0.265, p = 0.034$) (Figure 2).

The concentration of salivary melatonin shown by the participants of G3 was significantly higher than that of G1 and G2 in the mid-point and the day before the last day of the intervention (Bonferroni multiple comparison test: G1 versus G3, $p = 0.018$; G2 versus G3, $p = 0.011$), whereas there were no significant differences among the three groups on the day just before the start of the intervention (Kruskal Wallis test: $\chi^2$-value = 0.92, df = 2, $p = 0.63$) (Figure 3).

The “high implementation group” tended to show a higher concentration of salivary melatonin in MP than the “low implementation group” did in G3 (Mann-Whitney U-test: $z = -2.000, p = 0.071$) (Figure 4). Participants of G3 tended to follow the morning intervention recommendations (high protein breakfast and sunlight exposure) on more days than G2 participants did (Mann-Whitney U-test: FWP; $z = -1.952, p = 0.053$, MP; $z = -1.628, p = 0.015$, LWP; $z = 1.253, p = 0.221$) (Figure 5). The implementation rate in FWP tended to be higher than in MP (Wilcoxon’s signed rank sum test; G2; $z = -1.851, p = 0.064$; G3; $z = -1.914, p = 0.056$) and LWP (G2; $z = -2.298, p = 0.022$; G3; $z = -2.898, p = 0.004$). The implementation rate in MP tended to be also higher than in LWP in G2 and G3 (G2; $z = -1.681, p = 0.093$; G3; $z = -2.533, p = 0.011$).

Several parameters before and after the intervention period
There was a significantly positive correlation between the implementation satisfaction index (Maximum score: 100, Table 2) and the regularity of time to take breakfast and supper (Kendall tau-b test: breakfast, $r = 0.058$, $p = 0.038$; supper, $r^2 = 0.057, p = 0.036$).
There was a significant positive correlation between the index of how many days among the 30 days subjects were satisfied in their own implementation of the intervention (of having a breakfast that includes high protein foods) and M-E scores one month after the intervention (higher scores showing morning-type) (Pearson’s correlation test: \( r^2 = 0.195, p = 0.006 \)) (Figure 6).

There was a significant positive correlation between the number of nights when participants were exposed to incandescent light during the month-long intervention and the regularity index of meal time, not only for breakfast, but also for lunch and supper, just after the intervention (Kendall tau b-test: \( r = -0.574, p = 0.007, r^2 = 0.146, p = 0.084, r^2 = 0.215, p = 0.029 \)). Participants
Discussion
This study showed that a triple intervention concerning breakfast content, sunlight exposure after breakfast and exposure to low temperature light emitted from incandescent bulbs is a powerful method for inducing secretion of high amounts of melatonin by the pineal gland in human adults. Underlying mechanisms can be hypothesized to consist of two components. The first is that serotonin synthesis from tryptophan taken at breakfast may be enhanced by the exposure to sunlight just after taking breakfast. The second is that the high potential of melatonin synthesis based on the high serotonin synthesis in the pineal during daytime might be available due to the night exposure to the “low temperature light” emitted from incandescent bulbs. Although many reports have shown that melatonin secretion is suppressed by light emitted from fluorescent lamps including short wave length (with around 460 nm of wave length) components [25-27], and especially short wave length light [27-30], this study newly implies that the combined behaviors of modifying breakfast content, receiving sunlight exposure and receiving exposure to low color temperature lighting at night can facilitate achievement of high plasma melatonin at night in humans.

Melatonin, a hormone secreted from the pineal gland, causes the core body temperature to decrease and induces sleep [31-33]. High plasma melatonin levels at night may play an important role in sleep onset and sleep quality [34]. In this study, the longer time participants spent under incandescent lights at night, the significantly higher scores they marked to feel deep sleep. This better sleep quality might be due to high plasma melatonin levels.

This intervention study supports the hypothesis that the triple intervention of having sources of tryptophan and vitamin B6 at breakfast, following up breakfast with exposure to sunlight and the exposure to low temperature lights as night lighting can stimulate the synthesis of serotonin and succeeding melatonin synthesis at night and that these hormones work as natural anti-depression drugs and/or natural sleeping pills and make students more-morning typed and improve their mental health.

A limitation of this study as a “field intervention experiment” is that we did not include a control group with low-tryptophan breakfast, sunlight exposure, and exposure to low temperature light to find out the importance of the intake of tryptophan at breakfast for the mechanism of tryptophan-serotonin-melatonin pathway more clearly. This study was not a “physiological experiment” to set up several experimental groups and control all the environmental conditions, and such experiment remains to be conducted in the future. Another limitation of this study is that it was performed only with men, whereas the inclusion of participants from a female sports club could add important data on gender differences in response to breakfast modulation and the change in lighting at night.

Competing interest
The authors declare that they have no competing interests.

Authors’ contributions
KW: planned the study, conducted the intervention experiments, analyzed data, participated in the discussion of the results, and drafted the manuscript. SY: conducted the intervention experiments, analyzed data, and participated in the discussion of the results. OA: participated in the discussion of the results. TH: supervised the project, participated in the discussion of the results, and edited the manuscript. All authors read and approved the final manuscript.

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Author details
1Laboratory of Environmental Physiology, Graduate School of Integrated Arts and Sciences, Kochi University, Kochi, Japan. 2Department of Health and Physical Education, Faculty of Education, Kochi University, Kochi, Japan. 3Department of Health Education, Faculty of Education, University of South Bohemia, České Budějovice, Czech Republic. 4Department of Nutritional Education, Tokai Gakuen University, Miyoshi, Aichi, Japan.

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References

1. Moore P, Landolt HP, Seifritz E, Clark C, Bhatti T, Kelsoe J, Rapaport M, Gillin C. Clinical and physiological consequences of rapid tryptophan depletion. Neuropharmacology 2000, 38:601–622.

2. Zheng X, Beaulieu JM, Sotnikova TD, Garanetdinov RR, Caron MG. Tryptophan hydroxylase-2 controls brain serotonin synthesis. Science 2004, 305:2127.

3. Suzuki E. Serotonin and nerve cells, the brain and drugs. Tokyo: Seiwa Shoten; 2000:41–42. 109–116 in Japanese.

4. Linnola M, Higley D, Nielsen D, Andersen P, Suomi S, Goldman D, Vikrunkun M. Serotonin and impulse control: from clinic to clinic, in: Why? Neurupropharmacol 1993, 3:161.

5. Vain Piausa H. Anxiety-Attack driven depression: a paradigm of functionalization and verticalization of psychiatric diagnosis. Prog Neurupropharmacol Biol Psychiatr 2001, 25:893–924.

6. Deniau E, Cohen D. Selective serotonin reuptake inhibitors in childhood and adolescent depression: recent controversies. Psychiatr Clin Hum Neurosci 2005, 5:109–116.

7. Rosenthal N, Schwartz P, Tumer E, Nalm S, Matthews J, Hardin T, Barnett R. Selective serotonin reuptake inhibitors in childhood patients with delayed sleep phase syndrome. Correlation between serum melatonin levels. J Pineal Res 1990, 33:327–339.

8. Harada T, Nakade M, Wada K, Kondo A, Maeda M, Noji T, Takeuchi H. Mental health of children from a chronobiological and epidemiological point of view. (Chapter 22). In: Ensigns in Psychiatric. Edited by Rejika RO. Croatia: Intech; 2012. 580.

9. Palm C, Smith SA, Masa T, Korpela R. Dietary factors and fluctuating levels of melatonin. Food Nut Res 2012, 56: 17252. doi:10.3402/fnr.v56i0.17252.

10. Nowak R, Mcmillen IC, Smith KA, Khalsa SBS, Rajaratnam SMW, Reen EV, Gooley JJ, Chamberlain K, Smith KA, Khalsa SBS, Rajaratnam SMW, Reen EV, Yaroukouchi A, Hazama T, Kosaki T. Variations in the light-induced suppression of nocturnal melatonin with special reference to variations in the papillary light reflex in humans. J Physiol Anthropol 2007, 26:113–121.

11. http://www.jcircadianrhythms.com/content/11/1/4

12. Torsvall L, Åkerstedt T. A diurnal type scale: construction, consistency and validation in shift work. Scand J Work Environ Health 1980, 6:283–290.

13. Harada T, Inoue M, Takeuchi H, Watanabe N, Hamada M, Kadota G, Yamashita Y. Study on diurnal rhythms in the life of Japanese university, junior high and elementary school students including morningness-eveningness preference. Bull Fac Educ Kochi Univ Ser I 1998, 56:1–91 in Japanese.

14. Portulapipe F, Smolensky NH, Toutouy A. Effects and methods for biological rhythm research on animals and human beings. Chronobiol Int 2010, 27:1911–1929.

15. Hashimoto S, Nakamura K, Honma S, Tokura H, Honma K. Melatonin rhythm is not shifted by lights that suppress nocturnal melatonin in humans under entrainment. Ann J Physiol 1996, 270:H1073–H1077.

16. Zeiter JM, Dijk DJ, Kronauer RE, Brown EN, Czeisler CA. Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression. J Physiol 2000, 526:695–702.

17. Harada T. Effects of evening light conditions on salivary melatonin of Japanese junior high school students. J Circadian Rhythms 2004, 2:4. doi:10.1186/1740-3391-2-4.

18. Wright HR, Lack LC. Effect of light wavelength on suppression and phase delay of the melanatonin rhythm. Chronobiol Int 2001, 18:801–808.

19. Kayumov L, Casper RF, Hawa RJ, Perelman B, Chung SA, Sokalsky S, Shapiro CM. Blocking low-wavelength light prevents nocturnal melatonin suppression with no adverse effect on performance during simulated shift work. J Clin Endocrinol Metab 2005, 90:2755–2761.

20. Yasukouchi A, Hazama T, Kozaki T. In: Food and melatonin on sleep propensity, temperature, and cardiac activity at bedtime. Sleep-inducing effects of low doses of melatonin ingested in the evening. J Clin Pharm Ther 1995, 2265–273.

21. Nakade M, Takeuchi H, Taniwaki N, Noji T, Harada T. An integrated effect of protein intake at breakfast and morning exposure to sunlight on the circadian typology in Japanese infants aged 2-6 years. J Physiol Anthropol 2007, 26:201–207.

22. Nakade M, Akimitsu O, Wada K, Krejci M, Noji T, Tanwaki N, Higuchi S, Takeuchi H, Harada T. Can breakfast Tryptophan and Vitamin B6 intake and morning exposure to sunlight promote morning-typology in young children aged 2-6 years? J Physiol Anthropol 2013, 31:11. http://www.jphysiolanthropol.com/content/31/1/11.

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