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A PRELIMINARY STUDY ON INFLUENCE OF NEGATIVE AIR IONS GENERATED FROM PAJAMAS ON CORE BODY TEMPERATURE AND SALIVARY IgA DURING NIGHT SLEEP

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Abstract.
Objectives: This study was conducted to examine whether negative air ions generated from pajamas would influence the rectal temperature and the immune system during night sleep. **Materials and Methods:** Nine females (aged 18–23 years) served as participants. They slept during the night in their homes, wearing the pajamas with generation of negative air ions (1260 ions/cm^3) and with normal standard (520 ions/cm^3). The sequence of wearing the pajamas was: first, standard pajamas; second, pajamas with negative air ions; and third, standard pajamas again, each being worn for three consecutive days. **Results:** Rectal temperature in the pajamas with negative air ions tended to fall more significantly during the nighttime ($p = 0.068$). Salivary IgA tended to be higher on waking when wearing pajamas with negative air ions ($p = 0.094$) and its effect continued even after standard pajamas were worn again during last three days. **Conclusion:** These results suggest that the rectal temperature could possibly be more reduced and the elevation of salivary IgA more marked if the pajamas with negative air ions are worn during nocturnal sleep.

Key words:
Negative air ion, Core body temperature, IgA, Sleep

INTRODUCTION

Much interest has been given to possible effects of negative air ions (NAIs) on human health and well-being. According to Krueger and Reed [1], although air ions were already known in the end of the 19th century, and their possible effects on physiological responses have since been speculated, poor experimental methodology still confuses the exact understanding of any possible effects of NAIs.

The exposure to NAIs influences the performance of a number of psychomotor tasks [2]. In the hot environment (40°C), NAIs significantly reduced the heart rate and rectal temperature during exercise [3], and the reduction in rectal temperature produced by negative air ions occurred immediately. Reilly and Stevenson [4] also showed that NAIs significantly decreased rectal temperature during and after exercise. In addition, Ryushi et al. [5] reported

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that the exposure to NAIs during recovery after moderate exercise influenced the cardiovascular system in humans.

Charry [6] showed that the ion levels of 10^4 ions/cm^3 would be expected to produce biological responses. In the majority of cases, the subjects were exposed to NAIs for less than 2 h, and only few studies dealt with the effects of NAIs exposure longer than 2 h on human physiological responses.

Recently, Livanova et al. [7] demonstrated that NAIs in an acute immobilization stress exerted protective effects on respiratory enzymes in rats. In mice exposed to negative air ions before an intranasal dose of influenza virus, there was a decreased cumulative mortality rate compared to mice exposed to positive air ions [8]. These results are very interesting as they suggest the relation between NAIs and the immune system. However, the studies of the effects of exposure to negative air ions on the human immune system are rare.

Deeper sleep during the night-time can be induced under the influence of the nocturnal lower level of core temperature [9,10]. As mentioned above, NAIs could reduce rectal temperature during and after exercise [4]. Bearing this in mind, one may expect that in persons wearing during the night-time the pajamas which could generate negative air ions, the rectal temperature is much more reduced, and thus more deeper sleep induced.

Our present experiment was conducted to examine whether the pajamas with negative air ions generation could reduce the rectal temperature during night sleep and influence salivary immunoglobulin A (IgA) as an indicator of immune responses.

MATERIALS AND METHODS

Nine young female adults, mean age 20.1 years (SD 1.8), range, 18–23 years, served as participants. They did not smoke or consume alcohol. At the time of the study when the participants attended the experiment, they were all during the follicular phase of their regular menstrual cycle. They were in good health condition and did not suffer from any sleep disorders. The purpose and risks of the study were explained before the participants gave their written consent, and they were allowed to withdraw from the experiment at any time. However, we did not explain our hypothesis to all participants. The ethical committee of Nara Women's University approved the experiments, which were carried out between May and July of 1999. During the experiment, each room temperature ranged from 17°C to 20°C. All experiments were performed in a private home of each participant. All participants slept as usual at night wearing either standard pajamas (Control), or experimental ones that generate NAIs (N). Both pajamas consisted of 100% cotton fabrics and had the same thickness and design, long sleeves and full trousers. The cotton cloth was immersed in emulsificated liquid from the powder of rare mineral matter and then dried. Using external and internal cylinders with double cylinder detector, named Gerdien condenser, we measured negative air ions. The number of NAIs generated from Control was 520 ions/cm^3 and from N 1260 ions/cm^3. The measurements were taken by Ion Density tester (Cado, 57, Japan) in laboratory condition. The touch sensation to the pajamas did not differ between Control and N.

The participants wore standard pajamas (Control 1) for the first three days during sleep, pajamas with negative air ions for the next three days, and then again standard pajamas (Control 2) for the last three days. The sleeping environments (ambient temperature, sleeping condition) were kept nearly equal for each participant throughout the nine days. These participants were not aware of the order of the pajamas they wore.

Rectal temperature was measured continuously during night sleep at 5 min intervals using LT data logger (LT-8, Gram, JAPAN). To assess the life style and sleep habits of each participant, ambulatory activity monitoring equipment (Actiwatch model-AWL, Mini-Mitter, USA) was used during 9 days of experiment. The results concerning 2 participants were excluded because their sleep time was too irregular and the minimum of rectal temperature was far advanced compared with other participants.

Saliva was collected in a tube to measure immunoglobulin A (IgA) when the participant went to bed and woke up, then separated by centrifugation and stored at –50°C until analysis. This was measured by the latex fixation test in the

SRL laboratory (Tokyo). Intra-assay variation was 7.3% CV and inter-assay 7.5% CV.

The mean and standard error values were calculated. Differences between the mean values in N and Control conditions were tested by repeated two-way or one-way ANOVA. Huynh-Feldt (H-F) statistics was used to adjust the covariance matrix for violations of sphericity (Mauchly).

RESULTS

The mean of minimum rectal temperature for experimental sessions were 36.1°C (SEM 0.001) in Control 1. 36.01°C (SEM 0.124) in N and 36.07°C (SEM 0.115) in Control 2, respectively. These values did not differ significantly. The fall of rectal temperature after retiring during the third night of each part of the experiment is shown in Fig. 1. The fall of rectal temperature in N tended to be lower than in Control 1 ($F = 4.9$, $p = 0.068$), but there was no significant difference between N and Control 2 ($F = 2.5$, $p = 0.163$), or Control 1 and Control 2 ($F = 0.41$, $p = 0.54$).

Figure 2 shows a comparison of salivary IgA, when the participants went to bed and woke up between Control 1, N and Control 2. The values were obtained on the third day under each condition. The mean values of IgA when they went to bed were 14.5 (SEM 8.8) mg/dl in Control 1, 14.4 (SEM 2.9) mg/dl in N, and 12.2 (SEM 2.8) mg/dl in Control 2. The values of IgA when they woke up were 36.5 (SEM 8.8) ml/dl in Control 1, 54.5 (SEM 16.8) in N and 59.6 (SEM 17.8) ml/dl in Control 2. As seen here, there did not exist any difference when they went to bed ($F = 0.789$, $p = 0.423$). However, when they woke up, the value tended to differ under the influence of Control 1, N and Control 2 ($F = 3.87$, $p = 0.094$). After all, it seems that the value did not recover to original one from N to Control 2, but continued to rise.

Fig. 1. The fall in rectal temperature from sleep onset for 6 h during the third night of each part of the experiment under the influence of Control 1, N and Control 2. Values were means ± SEM. N = 7.

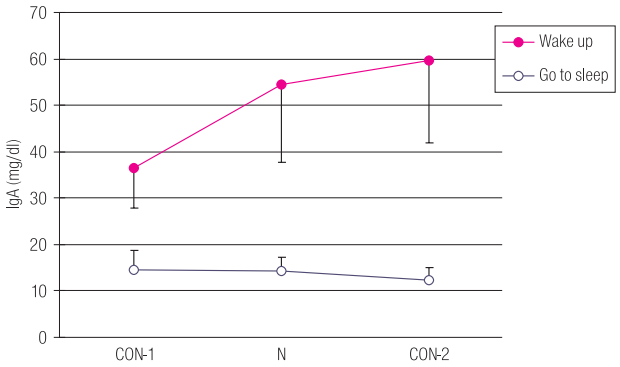

Fig. 2. Salivary IgA during the third night of each section under the influence of Control 1, N and Control 2. Closed circles: the samples were collected when the participants woke up. Open circles: the sample were collected when the participants went to bed. Values were means ± SEM. N = 7.

DISCUSSIONS

It is interesting to notice in our field study that the fall of the rectal temperature tended to become higher and IgA tended to increase under the influence of wearing the pajamas with NAIs generation. The fact that the fall of rectal temperature tended to be greater during night sleep under N might be due to the field study, in which we could not strictly control the environmental conditions and the daily life of the participants. Taking into account the results by Inbar et al., Reilly and Stevenson [3,4] as well as our present results, it is probably true that the rectal temperature could fall more deeply under the influence of NAIs. As deeper fall of core temperature during night sleep could induce deeper sleep during the night-time [10], it seems significant to wear the pajamas with NAIs generation during night sleep.

Exposure to NAIs in the early morning has been shown to be as effective as light therapy for winter depression [11]. Bright light exposure during the daytime increased nocturnal salivary IgA secretion more markedly in comparison with dim light exposure [12]. Similarly, NAIs increased IgA secretion more markedly in our present experiment.

These results suggest that common physiological mechanisms might underlie an increase in salivary IgA under the influence of the exposure to NAIs and bright light. Bailey [13] reported that NAIs increased serotonin (5HT) metabolism, which is connected with pineal hormone, melatonin. Therefore, there is a possibility that exposure to NAIs would be effective in improving sleep depth, because melatonin is highly relevant to inducing deeper sleep by decreasing core temperature more deeply [10].

However, it should be noticed that IgA was kept to be higher even after the participants changed the pajamas from N to Control 2. It might reflect the fact that it takes a few days until IgA is withdrawn after it was once secreted [14], although further studies are necessary to reach definite conclusions. The rectal temperature did not completely recover to the original value obtained in Control 1 even on the third day during Control 2, which also suggests probable after-effects of N under the influence of standard pajamas producing low levels of N.

The ion level in our study was about 10^3 ions/cm^3. The effects of this low level of ions have not yet been reported [6]. In our study, rectal temperature and salivary IgA tended to be influenced by N during night-time. This might happen because the exposure time was long throughout the night (about 6 h) compared to the previous studies. However, it should be noted that this study was just only preliminary, covering a small group of subjects. Although further studies are needed to clarify the physiological role of NAIs, the results of our study suggest that wearing the pajamas with negative air ions during the nocturnal sleep could markedly reduce the rectal temperature and elavate salivary IgA.

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REFERENCES

1. Krueger AP, Reed EJ. *Biological impact of small air ions*. Science 1976; 193: 1209–13.
2. Hawkins LH, Barker T. *Air ions and human performance*. Ergonomics 1978; 21: 273–8.
3. Inbar O, Rotstein A, Dlin R, Dotan R, Sulman FG. *The effects of negative air ions on various physiological functions during work in hot environments*. Int J Biometeorol 1982; 6: 153–6.
4. Reilly T, Stevenson IC. *An investigation of the effects of negative air ions on responses to submaximal exercise at different time of day*. J Human Ergol 1993; 22: 1–9.
5. Ryushi T, Kita I, Sakurai T, Yasumatsu M, Isokawa M, Aihara Y, et al. *The effect of exposure to negative air ions on the recovery of physiological responses after moderate endurance exercise.* Int J Biometeorol 1998; 41: 132–6.
6. Charry JM. *Biological effects of air ions: A comprehensive review of laboratory and clinical data.* In: Charry JM, Kavent R, editors. *Air Ions: Physiological and Biological Aspects*. Boca Raton: CRC Press; 1987. p. 91–149.
7. Livanova LM, Levshina IP, Nozdracheva LV, Élbakidze MG, Airapetyants MG. *The protective effects of negative air ions in acute stress in rats with different typological behavioral characteristics*. Neurosci Behav Physiol 1999; 29: 393–5.
8. Krueger AP, Reed EJ, Day MB, Brook KA. *Further observations on the effect of air ions on influenza in the mouse.* Int J Biometeorol 1972; 18: 46–56.
9. Monroe LJ. *Psychological and physiological differences between good and poor sleepers*. J Abnorml Psychol 1967; 72: 255–64.
10. Wakamura T, Tokura H. *The influence of bright light during the daytime upon circadian rhythm of core temperature and its implications for nocturnal sleep*. Nurs Health Sci 2000; 2: 41–9.
11. Terman M, Terman JS, Ross DC. *A controlled trial of timed bright light and negative air ionization for treatment of winter depression*. Arch Gen Psychiatry 1998; 55: 875–82.
12. Park SJ, Tokura H. *Bright light exposure during the daytime affects circadian rhythms of urinary melatonin and salivary immunoglobulin A*. Chronobiol Int 1999; 16: 359–71.
13. Bailey WH. *Biological responses to air ions: Is there a role for serotonin?* In: Charry JM, Kavent R, editors. *Air Ions: Physiological and Biological Aspects*. Boca Raton: CRC Press; 1987. p. 151–60.
14. Abbas AK, Lichtman AH, Pober JS. *Functional anatomy of immune responses.* In: Abbas AK, Lichtman AH, Pober JS. editors. *Cellular and Molecular Immunology* 3rd ed, Philadelphia: W.B. Saunders Company; 1997. p. 232–46.