Research Report

Stress-Reducing Effect of Negative Air Ions

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Abstract

The effects of negative air ions on psychological stresses (i.e., the Stroop task and computer operation) were examined with biochemical indices of stress response (i.e., salivary chromogranin A (CgA) and cortisol). Both CgA and cortisol levels were increased by the Stroop task, and exposure to negative air ions somewhat attenuated the increase. On the other hand, only CgA level increased after computer operation and cortisol level did not. The increase in CgA level by computer operation was attenuated by exposure to negative air ions during the task. Exposure to the ions during the recovery period (a rest period after the task) was effective for a rapid decrease of CgA level, which had increased after the task. These effects of negative air ions on the computer operation were also observed by the subjective evaluation of stress with the State form of the State-Trait Anxiety Inventory questionnaire. Task performance of computer operation was slightly but significantly improved by the presence of negative air ions. These results suggest that negative air ions are effective for the reduction of and the prompt recovery from psychological stress.

Keywords: Negative air ion, Fragrance, Stress, Computer, Stroop, Chromogranin A, Saliva, STAI-S, Performance

1. Introduction

Recently, not only have many kinds of negative air ion generator become commercially available, but also various electrical devices (e.g. air conditioners, air purifiers, etc.) have been provided with the function of generating such ions. A number of negative air ions exist in places used for relaxation (e.g. in forests or near waterfalls) and are said to contribute, at least in part, to the positive effects of such places on human health; therefore, much attention has been paid to their effects on health and comfort. In fact, many reports have described the favorable effects of negative air ions.[1-3] A definitive conclusion as to their effects, however, has not been stated, because most reports have serious methodological flaws.[4] Furthermore, the effects of negative air ions on the stress encountered in daily life, such as working in an office, have not been examined physiologically. For verifying the favorable effects of negative air ions on such stress encountered in daily life, a sensitive method of detecting physiological changes induced by stresses is essential.

Chromogranin A (CgA) is a major soluble protein in adrenal chromaffin cells and adrenergic neurons.[5] We have found that human saliva contains a protein which binds to a specific antibody against human CgA, and that salivary CgA changes more rapidly and more sensitively to psychological stressors, such as making public presentations and driving a car on an expressway, than does salivary cortisol, which is a well-known stress hormone reflecting the hypothalamic-pituitary-adrenal (HPA) axis.[6] Also, Kanno et al.[7] suggest that salivary CgA reflects the activity of the sympathetic/adrenomedullary system, which responds more rapidly to stressors than does the HPA axis.[8]

In this study, first we examined the effects of negative air ions (alone or with fragrance) on CgA and cortisol in saliva during a strong psychological task (i.e., the Stroop task[9]). Then we evaluated the effects of negative air ions on computer operation.[10]

2. Effects of negative air ions and fragrance on the Stroop task

2. 1 Method

2. 1. 1 Subjects

Twelve males (aged 30-50) were involved in this study.

2. 1. 2 Negative air ions and fragrance

Negative air ions were generated by the corona discharge method. The fragrance used in the experiment ("Deep Forest") was kindly donated by Shiseido Co (Tokyo, Japan). The concentrations of negative and positive air ions were measured by an ion tester (KST-900, Kobe-Denpa, Japan).

2. 1. 3 Design and procedure

Each experiment started with rest for 30 min, followed by the Stroop task for 60 min, and recovery for 30 min. In essence, this task consists of color-words that are printed in different colors, the combination of words and colors being incongruent; for example the word “blue” may be printed in red, etc. The subjects are instructed to ignore the word and report the color of the print.

The experimental conditions were as follows: 1) exposure to neither negative air ions nor fragrance, 2) exposure to only negative air ions, 3) exposure to both negative air ions and fragrance. The subjects were divided randomly into 3 groups (4 subjects in each group). The experiments were conducted according to a Latin square design, in order to prevent contamination of the order effect reflecting experience with the task. All subjects performed under all three of the experimental conditions. Room temperature and humidity were kept at 25±1°C and 50±5%, respectively.

2. 1. 4 Collection of saliva samples and measurement of CgA and cortisol

Saliva samples were collected at the end of the resting period (first sample), in the middle of the task (second sample), at the end of the task (third sample), 5 minutes after the end of the task (fourth sample) and at the end of the recovery period (fifth sample).

The concentrations of salivary CgA[11] and cortisol[6] were determined by enzyme-linked immunosorbent assay (ELISA). The levels were evaluated as relative changes against the value at the beginning of the experiment for each subject (=1).

2. 1. 5 Statistical analysis

Data were expressed as mean ± S.E. Statistical analysis was performed with the unpaired Student's t-test.

2. 2 Results and discussion

Both salivary CgA and cortisol levels were increased at 30 minutes (middle) and 60 minutes (end) after the start of the task (**Fig. 1**). The increased level of salivary cortisol remained almost unchanged 5 minutes after the end of the task. On the other hand, salivary CgA levels rapidly decreased after the task. This result is in concordance with the result obtained by the public speaking task.[6)]

Exposure to negative air ions alone (ca. 10,000 ions/cm^3) somewhat attenuated the increase in the levels during and at the end of the task (not statistically significant). Exposure to both negative air ions and the fragrance significantly decreased the levels. This result suggests stress-reducing effects of negative air ions and the fragrance as well as a cooperative effect between them. This experiment, however, was not a blind test, since the subjects could easily perceive the experimental condition (i.e., the presence of fragrance).

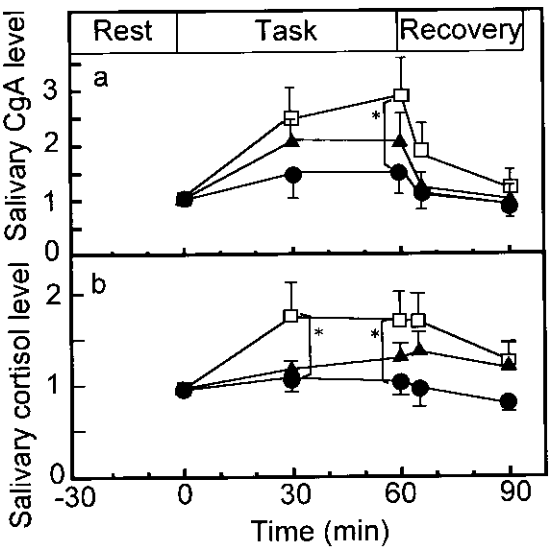

Fig. 1 Change of salivary CgA (panel a) and cortisol (panel b) levels during the Stroop task. The symbols used are: neither negative air ions nor fragrance generated (open squares), only negative air ions generated during both task and recovery periods (closed triangles), and both negative air ions and fragrance generated during both task and recovery periods (closed circles).

3. Effects of negative air ions on computer operation

3. 1 Method

3. 1. 1 Subjects

Twelve female undergraduate students aged 18-22 who did not have the skill of touch-typing were examined.

3. 1. 2 Design and procedure

Each experiment started with rest for 20 min, followed by word processing of handwritten manuscripts for 40 min and recovery for 30 min.

In the first experiment, the twelve subjects started the workload simultaneously under normal air conditions (i.e., without administering negative air ions). We measured salivary cortisol and CgA during the workload and determined the appropriate index for evaluating this workload.

In the second experiment, the effects of negative air ions on the workload were evaluated by reference to the index selected in the first experiment. The experimental conditions were as follows: 1) no exposure to negative air ions throughout work and recovery, 2) exposure to negative air ions during only the working period, 3) exposure to negative air ions during only the recovery period. The subjects were divided randomly into 3 groups and the experiments were conducted according to a Latin square design. As a negative control, subjects sat without working. Room temperature and humidity were kept at 25±1°C and 50±5%, respectively.

Saliva samples were collected at the end of the resting period (first sample), at the end of the task (second sample) and at the end of the recovery period (third sample).

3. 1. 3 Self-report questionnaire

The Japanese version of the State-Trait Anxiety Inventory-Anxiety State (STAI-S)[12,13)] questionnaire was used for subjective evaluation of stress. The questionnaire was filled out at the same time saliva was collected.

3. 1. 4 Statistical analysis

Data were expressed as mean ± S.E. Statistical analysis was performed with the Student's t-test to examine the effect of negative air ions on CgA and STAI-S score (unpaired) and task performance (paired).

3. 2 Results and discussion

3. 2. 1 Changes in salivary cortisol and CgA by computer operation

Prior to evaluating the effect of negative air ions on computer operation, the changes in salivary CgA and cortisol by the task were examined. CgA level increased more than three fold during the task, but salivary cortisol level did not increase.[10]

Although the task was difficult for the students, they might not have felt much stress, because they were familiar with computers. This may be the reason why salivary CgA increased but cortisol did not; the increase in salivary CgA is more sensitive to mild stressors than is cortisol.[6]

We, therefore, adopted only salivary CgA as the index of stress response in the subsequent experiment.

3. 2. 2 Effect of negative air ions on salivary CgA level

When negative air ions were not generated (background level: less than 50 ions/cm^3) the salivary CgA level increased almost four fold on working and decreased slightly on recovery (**Fig. 2**). The generation of ions (5,500-7,300 ions/cm^3) during working significantly attenuated the increase. Generation during recovery period was also effective for a prompt decrease in CgA level that had increased after working.

3. 2. 3 Effect of negative air ions on STAI-S score

When negative air ions were not generated, the increase of STAI-S score after working was not clear. Exposure to the ions during working significantly decreased the score (**Fig. 3**). Exposure to the ions during the recovery period decreased the score almost to the negative control level, but the decrease was not statistically significant.

3. 2. 4 Effect of negative air ions on task performance

Task performance improved slightly but significantly by the generation of negative ions during the task (**Fig. 4**). Although the degree of improvement was small, a great impact might be expected, because many workers use computers in daily life.

4. Conclusion

Exposure to negative air ions is effective for the reduction of and prompt recovery from stress

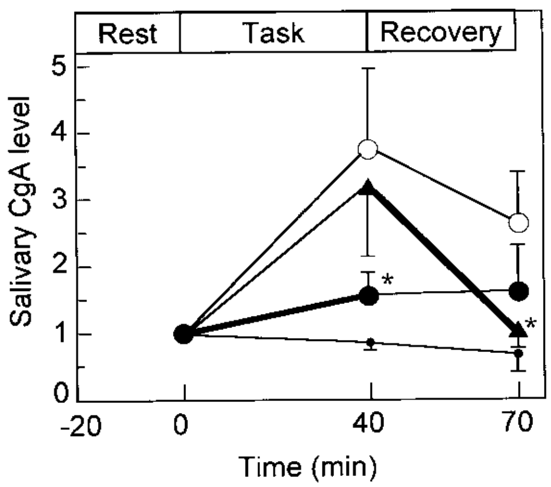

Fig. 2 Change of salivary CgA level during computer operation. The symbols used are: negative air ions not generated throughout experiment (open circles), and ions generated during working (closed circles) and recovery (closed triangles). Small circles represent a negative control (simply sitting without ions). The bold lines indicate the periods when ions were generated. ∗: $p<0.05$ (in comparison with the case where ions were not generated throughout the experiment).

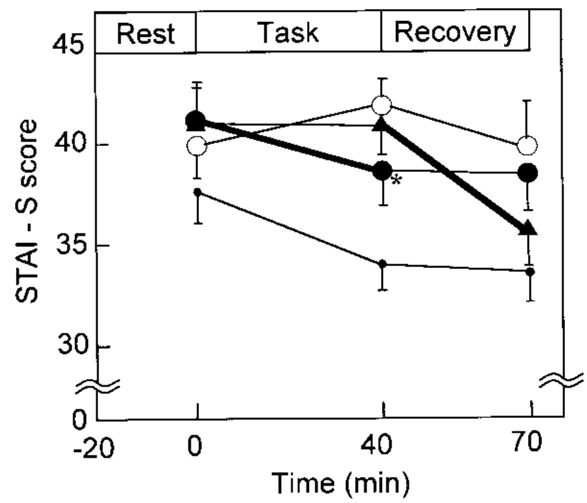

Fig. 3 Change of STAI-S score during computer operation. The symbols and lines used are the same in Fig. 2. ∗: $p<0.05$ (in comparison with the case where ions were not generated throughout the experiment).

induced by the computer operation task. These effects were ascertained by biochemical evaluation of stress response (i.e. salivary CgA). Evaluation by self-report questionnaire (i.e. STAI-S) also supported the effect. Negative air ions have no odor. They can be applied in places where many people gather (e.g. offices, schools, libraries, etc.), because consideration of individual preference is unnecessary. As a further application, negative air ions can also be expected to mitigate psychosomatic distress, such as aromatherapy.

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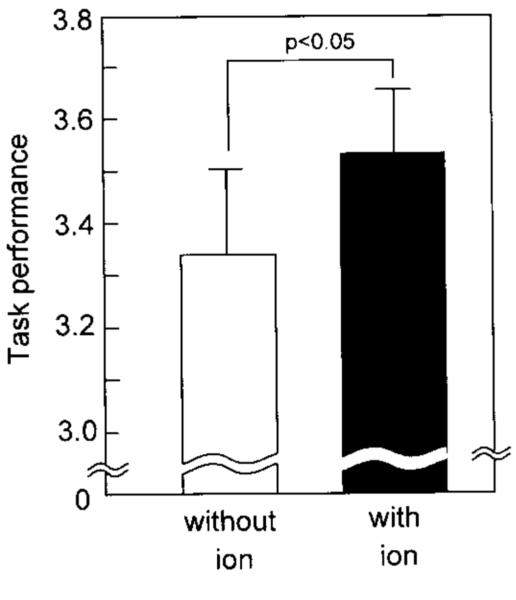

Fig. 4 Task performance as evaluated by the number of manuscripts completed within the working period.

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