



Influence of local air velocity from air conditioner evaluated by salivary and skin biomarkers

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ABSTRACT

The purpose of this paper is to reveal both the psychosomatic and the physical effects of local air velocity from an air conditioner using biomarkers which can be collected noninvasively. Salivary α -amylase activity (SAA) and salivary cortisol were used as the indexes of psychosomatic effects. The total protein (TP) collected from stratum corneum was used as an index of the physical condition of dry skin. A continuous experiment over a 5 days period in summer was conducted using 8 healthy young male adults for 2-types of airflow conditioners, a whole ceiling-type air conditioner (without local air velocity) and a normal-type air conditioner (with local air velocity). The subjects felt cool, windy, dry and uncomfortable when under the normal-type air conditioner as determined in a subjective evaluation. The SAA under the normal-type air conditioner fluctuated more widely than with the whole ceiling-type air conditioner. The level of salivary cortisol decreased more in a day under the normal-type air conditioner than with the whole ceiling-type air conditioner. These results showed that reducing local air velocity may provide more healthy psychosomatic conditions over the long-term. Moreover, the TP of a drying-exposed skin area showed a significant change during this experiment whereas the TP of a drying-protected area was relatively unchanged. It was indicated that one week's exposure to local air velocity conditions possibly influences the drying of facial skin. Thus, air movement at low velocity can be provides more comfortable conditions not only psychosomatically but also physically.

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1. Introduction

In order to maintain thermal comfort and high air quality, air conditioners are used to deliver the amount of supply air into confined spaces. The airflow from them sometimes causes discomfort as a psychosomatic effect and it may affect office work performance [1,2]. It is indicated that even though the development of novel air conditioners such as a heating, ventilation and air-conditioning (HVAC) system may allow for fully automated indoor environment quality (IEQ) control, such systems should not compromise occupants' perception of having some degree of control of their indoor environment [3]. Moreover, the airflow causes dry skin and dry eyes as physical effects. Dry skin has a low level of sebum and can be prone to sensitivity. The skin has a parched look caused by its inability to retain moisture. Various

types of novel air conditioners such as a floor-based task conditioner system [4], a floor-standing air conditioner [5] and a task/ambient conditioning system [6–8] have been proposed to provide a comfortable ambient environment. However, the relationship between skin condition and the effects of airflow has not been reported sufficiently.

In order to improve airflow conditions in a living space, the authors have already proposed a whole ceiling-type air conditioner. The novel air conditioner exhaust dispersed airflow from the whole ceiling by using a 3-dimensional knit fabric on the air outlet. Previously, an acute stress evaluation of subjects under the whole ceiling-type air conditioner has been reported using salivary α -amylase activity (SAA) as an index of the sympathetic nervous activity [9]. However, a long-term stress evaluation is needed in order to reveal the usefulness of the whole ceiling-type air conditioner. The purpose of this paper is to reveal not only the relationship between the psychosomatic effects and local air velocity, but also the relationship between face skin condition as a physical effect and the local air velocity over a 5 days period. The protocol was designed to use human biomarkers as indexes that could be collected noninvasively. SAA and salivary cortisol were used as the

Abbreviations used: SAA, salivary α -amylase activity; TP, total protein.

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indexes of psychosomatic stress. Using salivary biomarkers has the advantage that it is noninvasive, which makes multiple sampling easy and does not introduce distress. SAA is known to increase slightly with increased flow rates of saliva, and large increments in amylase concentration have been observed during sympathetic control by Speirs et al. [10]. Taking β -blockers significantly decreases the secretion of SAA, this provides direct evidence for the sensitivity of SAA to change in adrenergic activation [11]. Currently, it is considered that measurement of this SAA is a useful index of the plasma norepinephrine concentration under a variety of stressful conditions, since it appears that increased sympathetic nervous activity is a major stimulus of amylase secretion [12,13]. On the other hand, corticotrophin-releasing hormone (CRH) is one of the most important mediators of the stress response, coordinating the adaptive behavioral and physiological changes that occur during stress [14]. Salivary cortisol has advantages for analysis of stress in that (i) these hormones have a simple relationship with CRH; (ii) the concentrations of these hormones correlate significantly between plasma and saliva [15]. Thus, diurnal variation of cortisol concentration is one of the most useful physiological indexes of chronic stress [16].

Total protein (TP) collected from the stratum corneum of human skin has been used as an index of dry skin condition. It has been demonstrated that dry skin is related to a slight increase in the rate of continuous shedding and renewal (epidermopoiesis) [17]. Tape stripping is established as a simple technique for sampling or evaluating the function of the stratum corneum by using adhesive in dermatological research [18,19]. The most commonly used tape stripping method utilizes the D-Squame (Cuderm Corporation, Dallas, TX, USA). An instrument is on the market designed to indirectly measure the stratum corneum protein content on tape stripping [20].

In this paper, a continuous experiment over a 5 days period was conducted using 8 healthy young male adults (22.4 ± 0.7 yr, mean \pm standard deviation; SD) and 2-types of airflow conditions from either a whole ceiling-type air conditioner (without local air velocity) and a commercialized concentrated exhaust air conditioner (normal-type air conditioner, with local air velocity), where changes in the biomarkers were monitored. Subjective evaluations were conducted on each subject using a self-assessed questionnaire on the environmental assessment. The experiments were performed between July and August in an experimental room where the room temperature was cooled using the air conditioners.

2. Material and methods

2.1. Whole ceiling-type air conditioner

A whole ceiling-type air conditioner has a 3-dimensional knit fabric (1.77 m \times 0.89 m \times 2 seats; 3.2 m², Asahi Kasei Fibers Co., Japan) on the air outlet on the ceiling. The fabricated 3-dimensional knit fabric consists of a surface layer, a connecting fiber and a back layer

layer (thickness 11.5 mm, Fig. 1). When air pressure is applied on the surface layer of the 3-dimensional knit fabric, parallel-directed airflow is exhaled from the back layer.

The whole ceiling-type air conditioner consists of an air conditioner (S28FLV; 2.8 kW of cooling capacity, Daikin Industries Ltd., Japan), a blower tube and the 3-dimensional knit fabric and was installed in an evaluation room (W3.7 m \times L7.1 m \times H2.7 m, Fig. 2a and c). This air conditioner provides an equalized temperature and relative humidity environment by generating a parallel-directed airflow flow using the 3-dimensional knit fabric, which is installed on the ceiling (Fig. 2a). An air conditioner without 3-dimensional knit fabric was used as the normal-type air conditioner for the comparison (Fig. 2b). The evaluation room has a window (W1.8 m \times H1.8 m) and a door (W0.7 m \times H1.9 m, Fig. 2d). Eight sets of thermo-hygrometers (γ_h , γ_m , γ_l , γ_o and γ_c) were placed on the inside, outside and a corridor-side of the evaluation room. The mean air velocity was measured at the head of the subjects using an anemometer (Kanomax Japan, Inc., Japan).

2.2. Subjects and informed consent

We have limited the number of the subjects to 4 in a test because people usually feel uncomfortable to have a time with too many strangers in a room. Eight Japanese male adults subjects (aged between 21 and 23, 22.4 ± 0.7 yr) were enrolled in this study which was the maximum number in order to perform this evaluation in a summer season by using the same evaluation room. The mean BMI, weight, and height for the subjects were 25.2 ± 4.2 kg/m², 76.4 ± 13.5 kg and 173.7 ± 3.7 cm, respectively. The study protocol was approved by the Ethical Committee of Iwate University. The study protocol was fully explained to all of the subjects in both spoken and written forms, specifically focusing on the purpose of the study, the precise procedures that would be used and any possible adverse effects. Signed, informed, consent was obtained from each subject who enrolled in the study.

2.3. Subjective evaluation

In order to evaluate the feeling of the subjects, a self-assessed questionnaire on the room's environment was set consisting of 7 adjectives: *feel cool at head, feel cool at feet, feel cool in whole body, feel windy, feel dry, comfortable and sleepy*. The applicability of the adjectives to current mood was marked by the subjects on a 10 point scale between agree (+5), cannot say either or not (0) and disagree (−5) (Table 1).

2.4. Salivary biomarkers

SAA was analysed as an acute index of the sympathetic nervous system. The authors have manufactured a hand-held type SAA monitor (SAA monitor) which can be easily and quickly used for evaluating the activity of the sympathetic nervous system at any

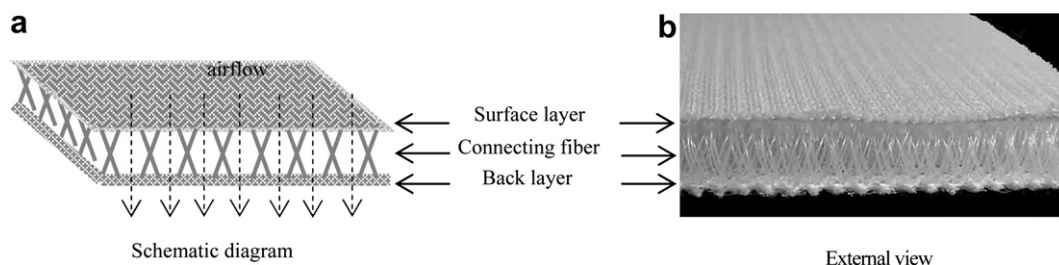


Fig. 1. A 3-dimensional knit fabric for a whole ceiling-type air conditioner used for without airflow to face (Asahi Kasei Fibers Co., Japan).

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