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Effects of Warm, Steam and Aroma Mask on Breathing Rhythm and Emotion

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Abstract

Objective: People generally use a mask to prevent inhaling or exhaling fine particles or bacteria. However, it hinders breathing to some extent and causes an unpleasant feeling. Therefore, it is necessary to improve the material of mask.

Methods: In this study, in 14 healthy male subjects we examined the effect and sensation or impression of aroma sheets (A), warm-steam sheets (WS) and warm-steam-aroma sheets (WSA) set in a mask. Respiratory rate (RR), State-Trait Anxiety Inventory (STAI) and visual analogue scale (VAS) for different feelings were analyzed during the application of a mask with (WS), (A) or (WSA) and compared with the results without such sheets.

Results: RR and state anxiety scores were decreased during the wearing of the masks. Differences in RR and state anxiety score showed a significantly linear positive correlation during WSA. Feelings of calmness, renewed energy, relaxation and good feeling were significantly increased during WSA.

Conclusion: The results suggest that warm-steam-aroma sheet is a useful material to set inside a mask to decreasing anxiety and increasing pleasant feelings.

Keywords: State-Trait Anxiety Inventory; Respiratory rate; Anxiety; Warm sheet; Warm-steam sheet; Aroma sheet; Pleasant feeling

Introduction

Masks are generally used to protect against the inhalation of surrounding microorganisms and particularly those from nearby coughs. In addition, masks are also to prevent the inhalation of fine particles. Although masks are very valuable, unfortunately wearing a mask can hinder breathing and render an unpleasant feeling. Therefore, it is necessary to develop masks which can be used comfortably.

It is known that respiration is the inhalation of oxygen and exhalation of carbon dioxide for energy metabolism and maintain homeostasis. This type of respiration, termed metabolic breathing, is generated in the respiratory centre located in the brainstem. Breathing also includes the so-called behavioral breathing which is different from metabolic breathing [1]. Behavioral breathing is elicited by various internal or external environmental changes. Breathing altered by emotional changes (emotional breathing) is included in behavioral breathing and the center for the so-called emotional breathing has recently been shown to be located in the amygdala in the limbic system [2]. Autonomic breathing rhythm is not only generated by metabolic demands, but it is also elicited by constantly responding to changes of emotions, such as anxiety, fear, sadness and happiness. Anticipatory anxiety, has been defined as the time between the warning presentation and stimulation, increases the respiratory rate [3].

It was shown that aroma evokes basic emotions [4] and some ambient aromas reduce anxiety [5-7]. Also breathing has been shown to be influenced and changed by aroma [2]. Pleasant aroma leads to slow and deep breathing, whereas unpleasant aroma results in fast and shallow breathing [8]. Aroma are often used with steam. The diffusion of aroma components of essential oil is widely performed with steam in the aroma therapy. In our daily life, we inhale and enjoy various aroma components with steam. For example, we drink coffee not only for enjoying the taste, but also for enjoying the aroma. Combinations of steam and aromas are used and adopted in human life. However, it is unclear how the combination of steam and aroma affects human emotion and breathing.

In this study, the influences of inhalation of steam, aroma (lavender plus mint) and a combination of steam and aroma on emotions and breathing were investigated in healthy males using mask.

Methods

Subjects

Seventeen healthy adult male subjects aged 26 to 52 years (38.6 ± 10.2 year: mean ± SD) participated in this study. Persons with heat or aroma allergies were excluded from the study. Age, height and body weight are shown in Table 1. Informed consent was obtained from all subjects, and the study was approved by the Ethics Committee of Tokyo Ariake University of Medical and Health Sciences.

Subjects	Age	Height (cm)	Weight (kg)	Trait
S01	26	180	74	48
S02	27	174	66	38
S03	46	176	81	41
S04	47	173	68	53
S05	30	175	60	63
S07	27	171	65	54
S08	47	167	69	50
S10	48	165	65	42
S11	49	172	72	41
S12	26	173	49	54
S13	47	160	70	37
S14	32	184	64	52
S15	36	177	62	40
S17	52	174	71	35
Mean ± SD	38.57 ± 10.2	172.9 ± 6.0	66.9 ± 7.4	46.3 ± 8.3

Table 1: Individual trait scores with age, heights and weights for 14 subjects.

Materials

Three different sheets were prepared to use as sources supplying warmed and humidified air:

- Warm- and steam-generating sheet (WS) (quantity of generated steam: 420 mg/10 min, Kao Corporation, Tokyo Japan),
- Non-warming aroma sheet (A) (amount of aroma perfume: 30 mg/sheet, no steam generation),
- Warm- and steam-generating aroma sheet (WSA) (amount of aroma liquid: 30 mg/sheet, quantity of generated steam: 420 mg/10 min).
- Non-warmed, non-steamed and non-aroma sheet (N) as a control was set in a mask before the application of WS, A or WSA. Each sheet was 6.3 cm square and 2 mm thick. Three-dimensional polypropylene masks were used in this experiment. The mask has two inner pockets bilaterally at the bridge of the nose. Two sheets of the special sheets of WS, A, WSA, or N were placed inside the pockets.

The warm-and steam-generating sheet generates warmed steam for 10-15 min through the reaction of iron powder with oxygen in the air, and the absolute humidity in the space of the mask is increased on heating and humidifying. The details of the warm-and steam-generating sheet have been described elsewhere [9,10]. The quantity of steam generated by the two warm- and steam-generating sheets was 840 mg/10 min within the mask. Lavender essential oil-based fragrance (90% weight %) combined with peppermint essential oil (10% weight %) was used for sheets A and WSA.

Measurements and evaluations of emotion and breathing

Subjects sat on a chair in a comfortable room where temperature and humidity were kept at 24°C and 50% RH, respectively. After 15 min acclimation, the subject wore a face mask containing sheet N for 10 min for baseline measurement, followed by wearing a face mask containing either sheet WS, A, or WSA for 10 min.

A respirometer (unrestrained-type respirometer TS03, Techno Science Co., Ltd.) was attached to the abdomen of the subject to measure respiratory movement as a measure of respiratory rate (RR). Data were recorded in a data logger (midi LOGGER GL820, Graphtec Co., Ltd., Yokohama, Japan). Respiratory rate (RR) was counted from the breathing waveforms in the final 5 min of wearing the mask.

Changes of mood during the experiment were measured by using STAI [11] and Visual Analog Scale (VAS). Categories and scales of mood measured by VAS were as follows: 'not energetic 0 mm – energetic 100 mm, 'not relaxed 0 mm – relaxed 100 mm, 'not feeling good 0 mm – feeling good 100 mm, and 'not calm 0 mm – calm 100 mm. The State-Trait Anxiety Inventory (STAI) is comprised two scales with 20 statements each that measure either trait or state anxiety.The state anxiety scale defines the anxiety experienced within a short time under specific conditions and is defined as 'right now' in various situations. The trait anxiety scale defines the general feelings of the individual and is defined as 'usual'. State anxiety was measured before and after wearing the mask under the three conditions. Taking any drinks and foods which might change a feeling and cigarette smoking were prohibited from 2 hours before the experiment. The order of wearing the three types of mask was chosen at random, -but was homogenously allocated to the 17 subjects beforehand. The subjects were instructed not to sleep during the experiment, but one slept during the experiment. Another subject took medicine for a cold immediately before the experiment and breathing could not be precisely measured in another subject. These 3 subjects were excluded, and the remaining 14 subjects were included in analysis.

Statistical analysis

Data are means ± SD. Two-way analysis of variance (ANOVA) was used to test for the effects of pre (N), post-applications and three types of masks on the variables measured. Separate effects of pre (N), post-applications and masks, and interaction between these two factors were determined. As a post hoc test, multiple comparison of masks on the variables during post-application was performed by Bonferroni's method to determine significant differences among three types of masks. For these analyses, we used SPSS II software (SPSS Japan, Inc., Tokyo, Japan). Statistical significance was set at $p<0.05$. Pearson's correlation coefficient was used to study the relationships between RR and state anxiety score. A p-value of <0.05 was considered statistically significant.

Results

Changes in STAI

Trait anxiety scores of 14 subjects varied from 35 to 63 and the mean score was 46 ± 8.27 (mean ± SD) (Table 1). The mean state anxiety scores were 35.5 ± 5.9 (mean ± SD) during WS, 35.9 ± 5.3 (mean ± SD) during A, 33.9 ± 3.9 (mean ± SD) during WSA, 37.9 ± 6.3 (mean ± SD) during N for WS, 38.7 ± 7.2 (mean ± SD) during N for A and 37.4 ± 5.4 (mean ± SD) during N for WSA. The mean state anxiety

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score during masks was significantly lower than N ($p<0.05$)(Figure 1). There was no significant interaction between the masks and N.

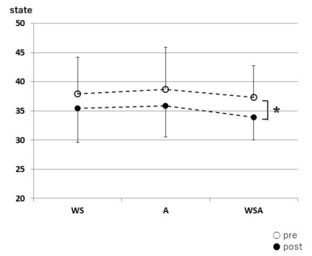

Figure 1: Changes in state. (WS): comparison of state between pre (N) and post (WS) application of warm-steam sheet (WS). (A): pre (N) and post (A) application of aroma sheet (A). (WSA): pre (N) and post (WSA) application of warm-steam aroma sheet (WSA). Values are mean ± SD. *Significant difference based on two-way repeated measures ANOVA ($p<0.05$).

Changes in respiratory rate (RR)

The mean RR measured before the application of WS(N) was 17.3 ± 2.3/min (mean ± SD), RR during WS decreased in 10 out of 14 subjects and the mean respiratory rate (RR) of all subjects was 16.5 ± 2.2/min (mean ± SD). The mean RR measured before all application of A(N) was 16.7 ± 3.2/min (mean ± SD). RR during A also decreased 10 out of 14 subjects and the mean respiratory rate was 16.2 ± 3.3/min (mean ± SD). The mean RR measured before the application of WSA (N) was 17.0 ± 3.0/min (mean ± SD). RR in WSA decreased in 11 out of 14 subjects and the mean respiratory rate was 15.8 ± 3.3/min (mean ± SD). The mean RR during the wearing of masks was significantly lower than the mean RR during N ($p<0.05$) (Figure 2). There were no significant interactions between the masks and N.

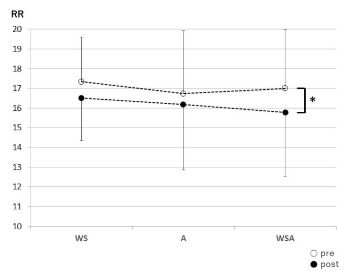

Figure 2: Changes in respiratory rate (RR). (WS): comparison of RR between pre (N) and post (WA) application of warm-steam sheet (WS). (A): pre (N) and post (A) application of aroma sheet (A). (WSA): pre (N) and post (WAS) application of warm-steam aroma sheet (WSA). Values are mean ± SD. *significant difference ($p<0.05$).

The relationships between differences of the state anxiety score (Δstate) and respiratory rate (RR)

Tendencies of positive correlations were observed between ΔRR and Δstate during WS ($p<0.12$) and A ($p<0.07$) (Figure 3). Significantly positive correlation was observed between ΔRR and Δ state during WSA ($p<0.05$) (Figure 3). The state anxiety scores tended to decrease as the respiratory rate decreased.

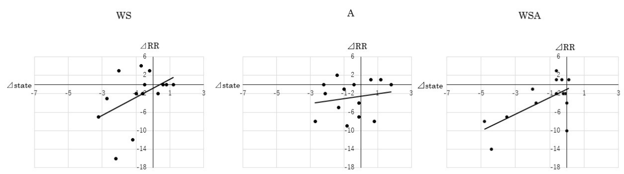

Figure 3: Correlations between changes in RR (⊿RR) and changes in state (⊿state) in (WS), (A) and (WSA). A significant positive correlation was observed in (WSA) ($p<0.05$).

Changes in VAS

Comparisons of calmness, energetic, relaxation and good feeling were examined between pre and post VAS scales in WS, A and WSA. The VAS scales in all 4 categories in post were significantly larger than the scales in pre ($p<0.05$) (Figure 4). There were no significant interactions in energetic, relaxation and good feeling, but in calmness. A post-hoc test showed that the scale of calmness in post WSA was significantly larger than the scale of calmness in post A ($p<0.05$).

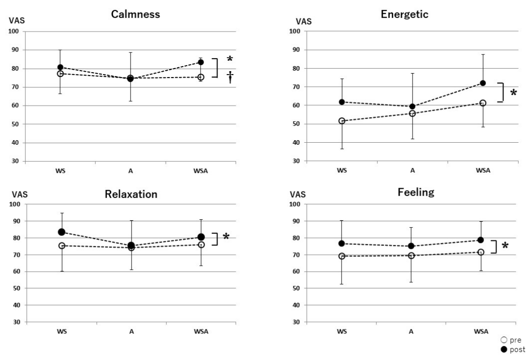

Figure 4: Changes in VAS of Calmness, Energetic, Relaxation and Good feeling. (WS): comparison of state between pre (N) and post (WS) application of warm-steam sheet (WS). (A): pre (N) and post (A) application of aroma sheet (A). (WSA): pre (N) and post (WSA) application of warm-steam aroma sheet (WSA). Values are mean ± SD. *significant difference between pre and post ($p<0.05$). † significant interactions ($p<0.05$).

Discussion

In this study, we examined the changes in respiratory rate (RR), state anxiety score and various moods during wearing a mask including a warm- and steam-generating sheet (WS), a non-warming and non-heating aroma sheet (A) and a warm-and steam-generating aroma sheet (WSA) in 14 healthy male subjects.

RR and state anxiety scores decrease in WS, A and WSA indicated that warm steam and aroma decreased RR and state anxiety. The close relationship between RR and levels of anxiety has been shown in previous studies [2]. In addition to studies on the relationship between arousal state and respiratory rate [12,13], the relationship between emotions and respiratory rates exposed to natural noise or unpleasant sounds has been reported [14,15]. RR is markedly changed as a result of emotional changes. Recently it has been shown that RR during quiet breathing is positively correlated with trait anxiety in human [16]. It was also shown that RR is increased during anticipatory anxiety and the increased RR shows a positive linear correlation with trait anxiety scores [17]. In the present study, we showed a significantly positive linear correlation between changes of RR (RR) and changes of state anxiety score (state) in WSA. The result indicated that a close relationship exists between RR and state in WSA.

Studies on neuroanatomical correlates of emotions and amygdala have revealed that the amygdala plays a role in processing emotions [18,19]. Several recent studies showed that respiratory rhythm is generated in amygdala and was related to emotion. Masaoka and Homma showed that activities produced during anticipatory anxiety appear in the amygdala [20]. This activity is synchronized with respiratory rhythm in humans [20]. Respiratory rhythmic activities have been recorded in the amygdala in a limbic brainstem-spinal cord preparation in newborn rats [21]. The preparation is a useful preparation to examine the relationship between spinal motor output of the phrenic nerve and neural activities in the brainstem and limbic system [22]. Neural rhythmic activities recorded from the amygdala are synchronized with the motor output of the phrenic nerve and the rhythmic activities remain after complete separation of higher brain regions from the lower brainstem by sectioning at the level of the pons. Frequencies of the respiratory rhythmic activities in the amygdala are increased when corticotrophin-releasing factor (a stress substance) is applied to the brain in the preparation [23]. These studies carried out in both humans and animals indicated that not only are respiratory rhythmic activities produced in the brainstem but also, they are produced in the amygdala [2]. The effects obtained in the study showing that RR and state anxiety scores are correlated and decrease by the application of warm steamed, aroma sheets may indicate that the source is in the amygdala. The aroma effect on RR and emotion has been shown. Masaoka et al. showed that the changes of RR induced by various aromas produced through piriform-amygdala complex related to olfaction [8]. They also showed that the pleasant aroma decreased RR and unpleasant aroma increased it [8]. The conspicuous effect was obtained by the application of the sheet combined with aroma and warm steam (WAS). Afferents including receptors activated by WAS were unclear. However, several reports have shown that local warming at about 40°C applied to lumbar or abdominal regions induced pleasant sensations [9,24]. Rolls showed that warming the hand of subjects at 41°C brought about a pleasant emotion and induced a significant neural activation in the orbito-frontal cortex, pregenual cingulated cortex and ventral striatum [25]. Warmth influences the human mind. Williams and Bargh reported that the person who held a warm coffee cup felt more warmth than the person who held a cold coffee cup [26].

Bargh and Shalev described that physical warmth applied to a man decreased his loneliness and feeling of social exclusion [27]. It has also been shown that social warmth and physical warmth induce neural activities in overlapping areas in the ventral striatum and middle insula [28,29].

Conclusion

Inhalation of moist air showed a more obvious effect on emotion in the study. It is known that the heat conduction rate is higher in moist air than in dry air. It may be thought that warm steamed air may induce a pleasant feeling by decreasing state anxiety through the nose, mouth and skin around the nose. Here the effects were also observed in the level of calmness, energetic, relaxation and good feeling. All of these moods were significantly increased using WSA. These results suggest that a mask with warm-steam-aroma sheets inside decreases the respiratory rate and state anxiety scores and increases pleasant feelings like calmness, energetic, relaxation and good overall feeling.

Conflicts of Interest

None of the authors have any financial conflicts of interest to declare as it relates to the contents of this manuscript.

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