The effect of six-weeks of sauna on treatment autonomic nervous system, peak nasal inspiratory flow and lung functions of allergic rhinitis Thai patients

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Summary

Background: **Allergic rhinitis is a chronic respiratory disease. Sympathetic hypofunction has been identified in allergic rhinitis patients.**

Objective: **To investigate the effects of six weeks of repeated sauna treatment on the autonomic nervous system, peak nasal inspiratory flow (PNIF) and lung functions in Thai patients with allergic rhinitis.**

Methods: **Subjects were diagnosed with allergic rhinitis clinically by an attending physician based on history, physical examination and positive reactions to a skin prick test. Subjects were randomly assigned to two groups. Control subjects received education and maintained a normal life. The sauna group received sauna treatment over a six-week period' 3 days per week, with 6 sets of 5 minutes per set per day' totaling 30 minutes. Each 5 minute set alternated with a 5 minute period of rest. Heart rate variability (HRV), peak nasal inspiratory flow and lung function were measured at the beginning and after three and six weeks of sauna treatment. The HRV measurement is composed of three components, including low frequency (indicating sympathetic function in normal units or n.u.), high frequency (indicated parasympathetic function in n.u.), and the ratio of LF/HF (indicating the balance of the autonomic system).**

Results: **Twenty-six allergic rhinitis patients, 12 males and 14 females participated in this study, 13 in the control group and 13 in the sauna treatment group; there were 6 males in each group. Baseline characteristics for the control and sauna treatment groups were comparable. There were significant changes in the HRV after six weeks of sauna treatment. The high frequency component was significantly lower in sauna treatment group (51.8 vs 35.4), while the low frequency component and LF/HF ratio were significantly higher in sauna treatment group than in the control group (48.1 vs 64.5 and 0.9 vs 2.5, respectively). The PNIF and the forced expiratory volume in one second, or FEV1, were also significantly higher in sauna treatment group (103.0 vs 161.9 and 80.1 vs 95.6, respectively).**

Conclusion: **The six weeks of repeated sauna treatment can increase sympathetic activity, PNIF, and FEV1 in Thai patients with allergic rhinitis.** ***(Asian Pac J Allergy Immunol 2013;31:142-7)***

Key words: *Autonomic nervous system, sauna, allergic rhinitis, lung functions, peak nasal inspiratory flow*

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Introduction

Allergic rhinitis is an inflammatory respiratory disease. The main symptoms are sneezing, rhinorrhea, pruritis and congestion. These symptoms occur when an affected individual is exposed to allergens, such as pollen, mite, dust and others. The study by Baraniuk showed that allergen is deposited in respiratory cells and influences the immune system.[1] Immonoglobulin E, in particular, binds to mast cell and releases inflammatory mediators such as histamine, prostaglandins, and bradykinin causing glands to secrete mucous. A previous study by Ishman et al. evaluated the relationship between allergic rhinitis and the autonomic nervous system (ANS).[2] They suggested that ANS dysfunction, especially sympathetic hypofunction, was present in all of the allergic rhinitis patients. Sympathetic hypofunction causes nasal congestion and decreases peak nasal inspiratory flow (PNIF).[3]

Allergic rhinitis patients are also at risk of asthma.[4-6] Evaluation for possible concurrent asthma should be carried out in allergic rhinitis patients. The principles of treatments for allergic rhinitis are allergen avoidance, pharmacotherapy, immunotherapy and patient education.[7] Alternative treatments such as phytotherapy and acupuncture have been reported in recent years.[7] Sauna therapy is one of alternative treatments, providing dry air and a high temperature, the recommended temperature being 80 to 100 degrees Celsius.[8] The usual sauna treatment consists of a short stay of 5 to 20 minutes followed by a cooling period. In the sauna, skin temperature increases rapidly leading to increase skin blood flow. The sudden exposure to a cold temperature after sauna treatment activates constriction of skin blood vessels. The resulting change in ANS function can cause a change in PNIF and also lung function. Thus, the aim of this study was to investigate the effects of six weeks of sauna treatment on ANS function, PNIF and lung functions in Thai patients with allergic rhinitis.

Methods

The present research was a cross sectional study conducted at the Department of Physical therapy, Faculty of Associated Medical Science, Khon Kaen University, Thailand.

Subjects

Patients clinically diagnosed with allergic rhinitis were invited to participate in the study. The inclusion criteria were: age between 18 and 30 years and positive skin prick tests. Those included had not taken any allergic rhinitis medication for three weeks. Patients were excluded if they had a history of asthma, other chronic respiratory diseases, cardiovascular disease, hypertension, diabetes mellitus, orthopedic problems, a neuromuscular disorder, liver or kidney disease, an open wound, evidence of infection, fever and those could not bear extreme hot or cold weather. They were informed about the nature and risks of the experimental procedures, and all subjects gave their consent to participate in the experiment. Subjects were randomly assigned to two groups. The control group (n = 13; 7 women, 6 men) received education and maintained a normal life. The xperimental or sauna treatment group (n = 13; 7 women, 6 men) received sauna treatment.

Study protocol

The trial was performed on each subject in the following order at the laboratory. First, they were asked about the frequency of their symptoms and drug usage. Anthropometric measurements including height, body weight, body mass index (BMI) and measurements of blood pressure, heart rate, PNIF, lung functions and heart rate variability were performed. Data were collected at the beginning and after the third and sixth week, respectively. All subjects were asked not to take any allergic rhinitis medication during the study period. This study was approved by the Khon Kaen University Ethical Committee (HE531449) and conformed to the standards set by the Declaration of Helsinki.

Sauna treatment program

The temperature of the sauna (Rehabmed Co.Ltd., Thailand) was maintained at 80 to 90 degrees Celsius. The participants rested for 15 min before the sauna. Subjects received sauna treatment over a six- week period; 3 days per week, with 6 sets of 5 minutes per set per day; totaling 30 minutes. Each 5 minute set alternated with a 5 minute period of rest. Immediately after the sauna, subjects were reassessed, as described below.

Heart rate variability (HRV)

Subjects arrived at the laboratory after an overnight (8 hours) sleep and refrained from smoking, use oral decongestants, caffeine and alcohol on the day of the study. Subjects rested on a bed for 5 minutes, and their respiratory rate (RR) was measured before electrocardiogram (ECG) monitoring (Biopac system, Inc; USA). Lead 2 ECG monitoring was recorded for 15 min,[2] and the respiratory rate was measured again following the

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ECG. Repeated respiratory rate and ECG monitoring was done to ensure that subjects were in steady state.

Heart rate variability was analyzed by frequency domain (Biopac software acknowledge^{R} III version 3.9.1 for the MP 30, Biopac system, Inc; USA). The frequency domain was calculated by transformation using fast fourier analysis obtained from the power spectrum of HRV. The power spectral components were divided into 3 frequencies: very low frequency, low frequency (LF: 0.04 – 0.15 Hz) modulated by sympathetic system indicating sympathetic function, and high frequency (HF: 0.15 – 0.40 Hz) mediated by parasympathetic system indicating parasympathetic function.[9] All frequencies were transformed to a normalized unit to investigate the balance of ANS by LF/HF ratio. The unit for LF and HF is the 'normal unit' (n.u.).

Peak nasal inspiratory flow (PNIF)

Before measurement, subjects were informed about the nasal inspiratory flow meter (GP Supplies Ltd. Concept House, 6 McNicol Drive Park Royal, London). Subjects put the mask of the nasal inspiratory flow meter over their mouth and nose and then carried out a deep inspiraton through the nose after normal expiration. Participants attempted 3 trials. Investigators recorded the best peak nasal inspiratory flow in L/min.[10]

Lung function test

Before measurement, subjects were informed about the spirometer (MINATO Autospiro AZ-505; Japan). Basic information for the subjects was entered into the spirometer program before starting. Subjects put the mouth piece into their mouths. A nose clip was placed on each subject's nose before the start button was pressed. Subjects performed inspiration and expiration via the mouth piece 3 times, followed by a forced inspiration and a forced expiration. The investigator recorded the forced expiratory volume in one second (FEV1) and forced vital capacity (FVC).

Outcome measurement

The primary outcome measure was the ANS function. The secondary outcome measurements were PNIF and lung functions.

Statistical analysis

The ratio of LF/HF was the main outcome measure. From a previous study,[11] the average LF/HF ratio in allergic rhinitis patients is 1.6 ± 0.3, while it is 2.2 ± 0.4 in healthy controls. We assumed that sauna treatment would increase the LF/HF ratio to close to that of the normal controls. The sample size for each group was 4 with the alpha error of 0.05 and power of 80%.

All outcome variables were tested for normal distribution. If they were normally-distributed, student's t-test or a paired t-test was used to compare the mean values for the groups'and for pre- and post- therapy. If the data were not normally-distributed, a Wilcoxon rank-sum or a Wilcoxon signed-rank test was used to test the difference between the two independent groups or pre- and post- therapy. Data were analyzed using STATA software (version 10.1, Texas, USA).

Results

Baseline characteristics of patients

There were 32 patients diagnosed with allergic rhinitis, treated at Srinagarind hospital who signed informed consent forms to participate in the study. Six patients were excluded due to negative skin prick tests. In total, 26 allergic rhinitis patients (12 males and 14 females) were eligible. Of those, there were 13 patients in the sauna treatment and control groups and 6 were male in each group. There was no inter-group difference with regard to the baseline characteristics observed in this study (Table 1). None of patients took medication during the study period.

Table 1. Baseline characteristics of patients

Characteristics	Control	Sauna
Number	13	13
Gender (male/female)	6/7	6/7
Age (years)	26.6 (3.0)	26.0 (2.5)
Weight (kgs)	56.1 (8.6)	60.9 (17)
Height (cms)	1.65 (6.2)	166.0 (11.1)
BMI (kgs/m^2)	20.3 (2.0)	21.8 (4.6)
Systolic blood pressure (mmHg)	110 (12.6)	109.1 (19.4)
Diastolic blood pressure (mmHg)	69.2 (7.8)	70.2 (12.5)
Heart rate (bpm)	77.7 (11.9)	77.7 (10.3)
Low frequency (n.u.)	39.9 (11.6)	48.8 (14.7)
High frequency (n.u.)	60.0 (11.5)	54.9 (14.2)
Low/High frequency	0.7 (0.3)	0.9 (0.4)
PNIF	96.9 (19.5)	119.2 (46.4)
FEV1 (%)	80.3 (10.7)	77.5 (9.8)
FVC (%)	71.6 (8.9)	70.3 (11.1)
FEV1/FVC	96.1 (2.9)	95.2 (8.9)

Note: BMI; Body mass index**,** kg; kilogram, cm; centimeter, mmHg; millimeter mercury, bpm; beat per minute, n.u.; normal unit, PNIF; peak nasal inspiatory flow, FEV1; forced expiratory volume in one second, FVC; forced vital capacity. Values are mean (SD).

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Heart rate variability

There was a statistically significant difference in LF (n.u.), HF (n.u.) and the LF/HF ratio from baseline and at 6 weeks in both groups (Table 2). There was a statistically significant increase in LF (n.u.) and a decrease in HF (n.u.) after 6 weeks of sauna treatment compared with the control group (Table3).

Peak nasal inspiratory flow

There was a statistically significant increase in PNIF after 6 weeks of sauna treatment compared with baseline, while there was no change in the control group (Table 2). A statistically significant difference in PNIF after 6 weeks of sauna treatment compared with the control group was shown (Table 3).

Lung function

There was a statistically significant increase in FEV1 from baseline after 6 weeks in the sauna treatment group without any change in the FVC and the FEV1/FVC ratio (Table 2). There was a statistically significant difference increase in FEV1 after sauna treatment compared with the control group, while the FVC and the FEV1/FVC ratio were not significantly different (Table 3).

Table 2. Comparison of outcome variables at baseline and at the 6th week in the control and sauna treatment groups

Outcome	group	Baseline	6th week	*P*-value
LF(n.u.)	control	39.9 (11.6)	48.1 (9.8)	0.003
	sauna	48.8 (14.7)	64.5 (14.0)	0.002
HF(n.u.)	control	60.0 (11.5)	51.8 (9.8)	0.003
	sauna	54.9 (14.2)	35.4 (14.0)	0.004
LF/HF	control	0.7 (0.3)	0.9 (0.3)	0.004
	sauna	0.9 (0.4)	2.5 (2.3)	0.009
PNIF	control	96.9 (19.5)	103.0 (31.3)	0.394
	sauna	119.2 (46.4)	161.9 (46.7)	0.002
FEV1	control	80.3 (10.7)	80.1 (10.4)	0.896
	sauna	77.5 (9.8)	95.6 (5.7)	0.002
FVC	control	71.6 (8.9)	72.3 (10.0)	0.398
	sauna	70.3 (11.1)	75.0 (6.2)	0.135
FEV1/FVC	control	96.1 (2.9)	95.5 (4.8)	0.647
	sauna	95.2 (8.9)	95.6 (5.7)	0.302

Note: LF n.u.; low frequency normal unit, HF n.u.; high frequency normal unit, PNIF; peak nasal inspiatory flow, FEV1; forced expiratory volume in one second, FVC; forced vital capacity, Values are mean (SD); *p* value is the difference of value between baseline and 6th week in either control or sauna group.

Table 3. Comparison of outcome variables between the control and sauna treatment groups at the end of study

Variables	Control group N = 13	Sauna group N = 13	*P*-value
LF(n.u.)	48.1 (9.8)	64.5 (14.0)	0.003
HF(n.u.)	51.8 (9.8)	35.4 (14.0)	0.003
LF/HF	0.9 (0.3)	2.5 (2.3)	0.003
PNIF	103.0 (31.3)	161.9 (46.7)	0.001
FEV1	80.1 (10.7)	95.6 (5.7)	0.001
FVC	72.3 (10.0)	75.0 (6.2)	0.589
FEV_1/FVC	95.5 (4.8)	95.6 (5.7)	0.520

Note: LF n.u.; low frequency normal unit, HF n.u.; high frequency normal unit, PNIF; peak nasal inspiatory flow, FEV1; forced expiratory volume in one second, FVC; forced vital capacity , Values are mean (SD).

Discussion

The aim of this study was to investigate effects of a six-week period of repeated sauna treatments on ANS function, PNIF and lung function in Thai patients with allergic rhinitis. We measured the HRV to assess ANS function. The main finding of the present study is that ANS function was significantly changed after repeated sauna treatments.

An ANS imbalance was found in both groups (Table 2), especially sympathetic hypofunction in the allergic rhinitis patients, which agrees with the findings of previous studies.[2,3] Even though there were some changes in ANS function in the control group, those changes were small compared to the sauna treatment group. These findings may be the result of education and life style changes by the control subjects.[7]

We observed the response of the ANS by a significant increase in LF (n.u.) and the LF/HF ratio and a decrease in HF (n.u.) of HRV in the sauna treatment group after 6-weeks. The increase in LF (n.u.) and the LF/HF ratio in both groups after 3 weeks did not show a statistically significant difference and neither did the decrease in HF (n.u.) (Data not shown). The effects of sauna treatment were clearly demonstrated after the 6th week but not after three weeks.

After 6 weeks of treatment, LF increased from 48.8 to 64.5, LF/HF increased from 0.9 to 2.5, and HF decreased from 54.9 to 35.4 in sauna treatment group (Table 2). The activity of sympathetic function significantly increased after six weeks of repeated sauna treatment, as shown by the evidence of an increase in LF and the LF/HF ratio, while the lower HF indicated a decrease in parasympathetic activity

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after sauna treatment. These ANS function results were also different from those in the control group (Table 3).

Thermal modalities are safe, easy to use and inexpensive. Therapeutic effects of modalities on physiological function include the circulation system, neuromuscular function, and local and central neural activities.[12] Many previous studies focused on the effects of repeated sauna treatments on circulation, blood flow and immune responses caused by various temperatures of sauna therapy.[13-16] The conventional sauna bath egime consists of hot and cold cycles. The duration of stay in heat is about 5 to 20 minutes, followed by a cooling period and repeated sauna treatments depend on personal comfort.[13] Interestingly, skin blood flow increases during the heating period because of vasodilation and decreases during the cooling period because of vasoconstriction.[14,15] Charkoudian explained this phenomenon by the autonomic reflex which is associated with skin blood flow and is controlled by two branches of the sympathetic nervous system.[16] The sympathetic noradrenergic vasoconstrictor nerves control the decrease in skin blood flow in normothermia and in cold environments. On the other hand, the increase in skin blood flow is caused by activation of sympathetic vasodilator nerves and impeded sympathetic noradrenergic vasoconstrictor nerves.

Allergic rhinitis is a chronic respiratory disease. Nasal congestion and obstruction lead to air flow limitation. Allergic rhinitis patients always suffer from these symptoms. Normally, antihistamines do not relieve nasal congestion. The present study focused on nasal airflow measurement after sauna treatment. PNIF is the method used to detect changes in nasal airflow due to obstructive or inflammatory causes.[17] Interestingly, an increase in PNIF and FEV1 after 6 weeks of sauna treatment were detected. The significant increase in PNIF in the sauna treatment group may be explained by the effect of heat in clearing nasal cavity and increasing the airflow. Previous studies showed a decrease in nasal congestion after inhaling hot and humid air for 30 minutes.[18,19] This finding may be explained by inhibition of the neural and vascular responses. Moreover, the decrease in nasal congestion leads to an increase nasal cavity volume, resulting in increased PNIF.[20] Our study is different from the previous studies in terms of the temperature and methods used. The temperatures in this study were 80-90 degrees Celsius for the whole body, while other studies used local hyperthermia at 37 degrees Celsius.[19] Both temperature ranges had comparable results on nasal airflow.

Regarding lung function, only FEV1 in the sauna treatment group was significantly increased after 6 week of sauna therapy. The increase of bronchial smooth muscle endurance and strength from thermal therapy may improve the FEV1.[21] The FEV1 value in the sauna treatment group (77.5%) at baseline was slightly lower than normal (80.3%) but the FEV1/FVC ratio was normal, indicating that there was no obstructive airway disease.

The limitation of this study is the small number of participants but there was no gender difference between the study groups. The clinical outcomes of sauna treatment should also be studied. Our measurements were done immediately after sauna treatment so we did not have a 24-hour monitoring for neuronal changes. Therefore, continuous measurements for the whole day should be performed to show the persistent effects of sauna therapy.

In conclusion, sauna treatment can improve sympathetic activity, FEV1, and PNIF in Thai patients with allergic rhinitis.

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