Assessing the efficacy of a novel temperature and humidity control machine to minimize house dust mite allergen exposure and clinical symptoms in allergic rhinitis children sensitized to dust mites: a pilot study

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Summary

Background: **House dust mite avoidance is advised in dust mite sensitized patients to decrease the risk to develop allergic symptoms. Maintaining a relative humidity (RH) of less than 50% in households is recommended to prevent dust mite proliferation.**

Objective: **To investigate the efficacy of a novel temperature and humidity machine to control the level of dust mite allergens and total nasal symptom score (TNSS) in dust mite sensitized allergic rhinitis children.**

Method: **Children (8-15 years) with dust mite sensitized persistent allergic rhinitis (AR) were enrolled. The temperature and humidity control machine was installed in the bedroom where the enrolled children stayed for 6 months. TNSS was assessed before and every month after machine set up and the level of dust mite allergen (Der p 1 and Der f 1) from the mattress were measured before and every 2 months after machine set up using enzyme-linked immunosorbent assay (ELISA).**

Results: **A total of 7 children were enrolled. Noticeable reduction of Der f 1 was observed as early as 2 months after installing the machine, but proper significant differences appeared 4 months after and remained low until the end of the experiment (*p* <0.05). Although no correlation was observed between TNSS and the level of dust mite allergens, there was a significant reduction in TNSS at 2 and 4 months (*p* <0.05) and 70% of the patients were able to stop using their intranasal corticosteroids by the end of the experiment.**

Conclusions: **The level of house dust mite in mattresses was significantly reduced after using the temperature and humidity control machine. This machine may be used as an effective tool to control clinical symptoms of dust mite sensitized AR children.** ***(Asian Pac J Allergy Immunol 2015;33:129-35)***

Keywords: *allergic rhinitis, dust mite, der p 1, der f 1, children, relative humidity*

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Introduction

Allergic rhinitis (AR) is a common allergic disease. Worldwide, more than 600 million patients are suffering from AR. In Thailand, AR prevalence increased from 37.9% in the year 1995 to 50.6% in the year 2001.[1]

Clinical symptoms of AR consist of nasal itching, sneezing, watery nasal discharge, rhinorrhea, and blocked nose. Allergic rhinitis can be classified as intermittent or persistent and its severity from mild to severe. Preferred medication treatments include antihistamine, oral leukotriene receptor antagonists, and topical nasal corticosteroids depending on disease severity, [2] although allergen avoidance is advocated as a central preventive measure for the managements of AR.[3] House dust mite is the most common aeroallergen sensitization in patients with respiratory allergy in tropical countries such as Thailand and Singapore.[4,5] A recent practice parameter has advised dust mite sensitized patients with asthma or rhinitis to minimize exposure to dust mite allergens in order to decrease their risk of developing symptoms. Considering that water balance is an important determinant of house dust mite survival, adjusting humidity in households to levels that limit house dust mite proliferation is believed to be a key preventive measure in order to minimize AR risks. Optimal relative humidity (RH) for house dust mite growth is 65% and up. If humidity is reduced to levels below 55%, mite survival decreased. Considering that ambient temperature has a strong influence on RH variation, maintaining stable optimal temperature is important to maintain a stable RH.[6] The present study aimed to investigate the effects of a novel temperature and humidity control machine on the level of dust mite allergens and clinical symptoms of dust mite sensitized allergic rhinitis children. This machine was invented by Dr. Veerapon Monyakul from,King Mongkut's University of Technology Thonburi, Thailand. This machine has been shown elsewhere to maintain a precise temperature and desired humidity in the room for extensive periods of time.[7]

Methods

Patients

Children aged 8-15 years with persistent allergic rhinitis according to Allergic Rhinitis and its Impact on Asthma (ARIA) guidelines, [3] who had skin prick test positive to house dust mites (*Dermatophagoides pteronyssinus* and/or *Dermatophagoides farinae*) and who had symptoms of allergic rhinitis after exposure to house dust mite were eligible for the study. A positive skin test was defined as a wheal diameter at least 5 mm larger than the negative control (normal saline). Patients with multiple sensitization and previously or currently received specific immunotherapy were excluded. Since the temperature and humidity control machine operate with air-conditioning and the machine was installed in the bedroom, the enrolled patients' had air-conditioning in the bedroom.

Study protocol

This study last for 6 month with a 1 month run-in period. During the run-in period, intranasal corticosteroids were not allowed, but patients were allowed to use decongestant, antihistamine and nasal irrigation. At V0, the patients were evaluated for total nasal symptom score (TNSS) and dust samples were collected from the mattresses in the bedroom for dust mite allergen measurement. Subsequently, clinical examination was performed and TNSS was assessed every month after machine installation in the bedroom. The dust mite allergens (Der p 1 and Der f 1) were measured every 2 months (Figure 1). TNSS was defined as the sum of the average score in the past 4 weeks for the 4 individual patients for whom nasal symptoms of congestion, itching, rhinorrhea, and sneezing (0-3 from mild to severe) have been reported. After enrollment, patients were treated for their rhinitis according to ARIA guideline[3] and received standard recommendations for dust mite control. The study was reviewed and approved by the human rights and ethic committee of Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand. All enrolled patients and guardian gave their consent after formal and detailed explanation of the study objectives.

The temperature and humidity control machine

The temperature and humidity control machine was invented by Dr. Veerapon Monyakul, King Mongkut's University of Technology Thonburi, Bangkok, Thailand.[7] The machine is made of a humidifier unit and a dehumidifier unit contained in the same case. The device is 0.3 x 1.0 x 1.2 meters (Width x Length x Height) and is similar to a 10,000 BTU air condition (type TURBO A.P.S., Saijo Denki International Co., Muang Nonthaburi, Thailand). This device does operate with air-conditioning with automatic control by microprocessor to keep the relative humidity and temperature constant at, 55% RH and 25°C (Figure 2). The temperature was controlled permanently while the 16-20 square meter room was occupied by the patients, but left uncontrolled while the room was not used. Humidity was permanently set to 55%. Patients were asked to remain in their bedrooms at least 8 hours per day. The temperature and humidity control machine has never been used as a commercial product.

Mite Allergen Measurement

Levels of Der p 1, the major allergen of *Dermatophagoides pteronyssinus* mites, and Der f 1, the major allergen of *Dermatophagoides farinae*, were measured using the commercial sandwiched ELISA reagents (Indoor Biotechnology, U.K.) at Siriraj Dust Mite Center for Services and Research, Department of Parasitology, Faculty of Medicine Siriraj Hospital Mahidol University, Bangkok, Thailand. The lower detection limit is 0.2 μg of Der f 1 and Der p 1 per gram of dust.

Statistical analysis

Descriptive analysis was used to report the mean value and standard deviation (SD) of the data. Comparative analysis between pre and post machine installation was analyzed using paired Student's *t test* or repeated measures ANOVA. Correlation between TNSS and the level of dust mite allergen was analyzed using Pearson correlation. Differences with a p value <0.05 were considered statistically significant. Data were analyzed using SigmaPlot 12.

Results

A total of 7 children with house dust mite sensitized allergic rhinitis were enrolled. Four children were males, mean age was 9.8 years, mean age of onset was 4 years and mean duration of symptom was 4 years. Three children also had asthma. Baseline characteristic of the patients is shown in Table 1.

Total nasal symptom score (TNSS) after installing the machine

TNSS was significantly reduced 2 months after installation of the machine. However due to the important variation in the TNSS and the small sample size, this reduction was statistically significant only at 2 months and 4 months after installation (Figure 1). Five out of seven patients were able to stop using their intranasal corticosteroids during the experiment.

The level of Der p 1 and Der f 1 allergens after installation

There was a notable reduction of the levels of Der f 1 as early as 2 months after installing the machine but this reduction became significant only after 4 months and Der f 1 levels remained low until the end of the experiment ($p < 0.05$) (Figure 3). In contrast, the levels of Der p 1 in the mattresses were below 0.2 µg per gram of dust in 6/7 of the rooms resulting in non-significant changes (Figure 4).

The level of dust mite allergen and TNSS

There was no correlation between the TNSS and the level of Der f 1 or Der p 1 (Figure 5). Comparison between patients who had baseline TNSS above and below 3, did not yield significant results for the baseline levels of Der f 1 level (2.5 vs 1.4 µg/ gram dust, $p = 0.4$)

Discussion

House dust mite is a major allergen causing symptoms in respiratory allergy especially in tropical countries such as Thailand [5] where more than 70% of children with respiratory allergy are known to have been sensitized to house dust mites.[8] Current guidelines for allergic rhinitis and asthma management have emphasized the importance of minimizing allergen exposure and improving mite control as a fundamental preventive measure. Environmental exposure to dust mites can be

Table 1. Baseline characteristic of participating children

	Age (yr)	Sex	Duration of AR (yr)	Age of onset (yr)	Other allergic diseases	Severity of AR	Wheal size for Dp bySPT	Wheal size for Df By SPT	Baseline TNSS
1	12	M	1	7	Drug allergy	Mild persistent	6*5	8*6 with pseudopod	3.45
2	12	F	7	4	AD,food allergy	Mild persistent	9*7	12*6 with pseudopod	1
3	8	M	2	6	No	Moderate persistent	10*5 with pseudopod	10*5 with pseudopod	6
4	8	M	6	2	Asthma	Mild persistent	7*7	10*6	1
5	11	F	4	7	Asthma	Moderate persistent	10*6	16*15	7.6
6	10	M	1	8	No	Mild persistent	10*25	10*8	3
7	8	F	7	1	Asthma	Mild persistent	17*15	23*13	1.83

AR : Allergic Rhinitis, SPT : Skin Prick Test, TNSS: Total Nasal Symptom Scores

Df = *Dermatophagoides pteronyssinus* , Dp = *Dermatophagoides farinae*

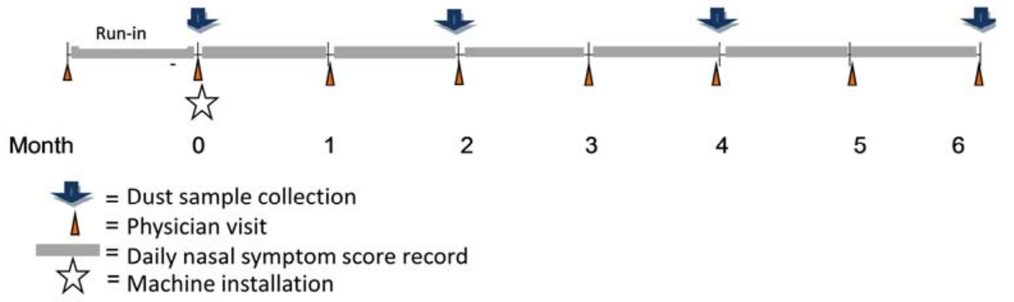

Figure 1. Study protocol

mite populations removal.[6] A key factor for mite survival and proliferation is relative humidity (RH) in the ambient environment.[9] Maintaining RH below 55% in households has been recommended to control dust mites and their allergens in homes temperate regions.[10] Although RH is arguably the most important factor to control, steady temperature is needed to maintain RH stable over time. [6]

The present study has demonstrated that the novel temperature and humidity control machine, by allowing the maintenance of steady temperature and stable humidity below thresholds of mite proliferation, was able to decrease the level of dust mite allergens in the bedroom of allergic rhinitis patients from Thailand, a high humidity country. Previous studies have shown the ineffectiveness of

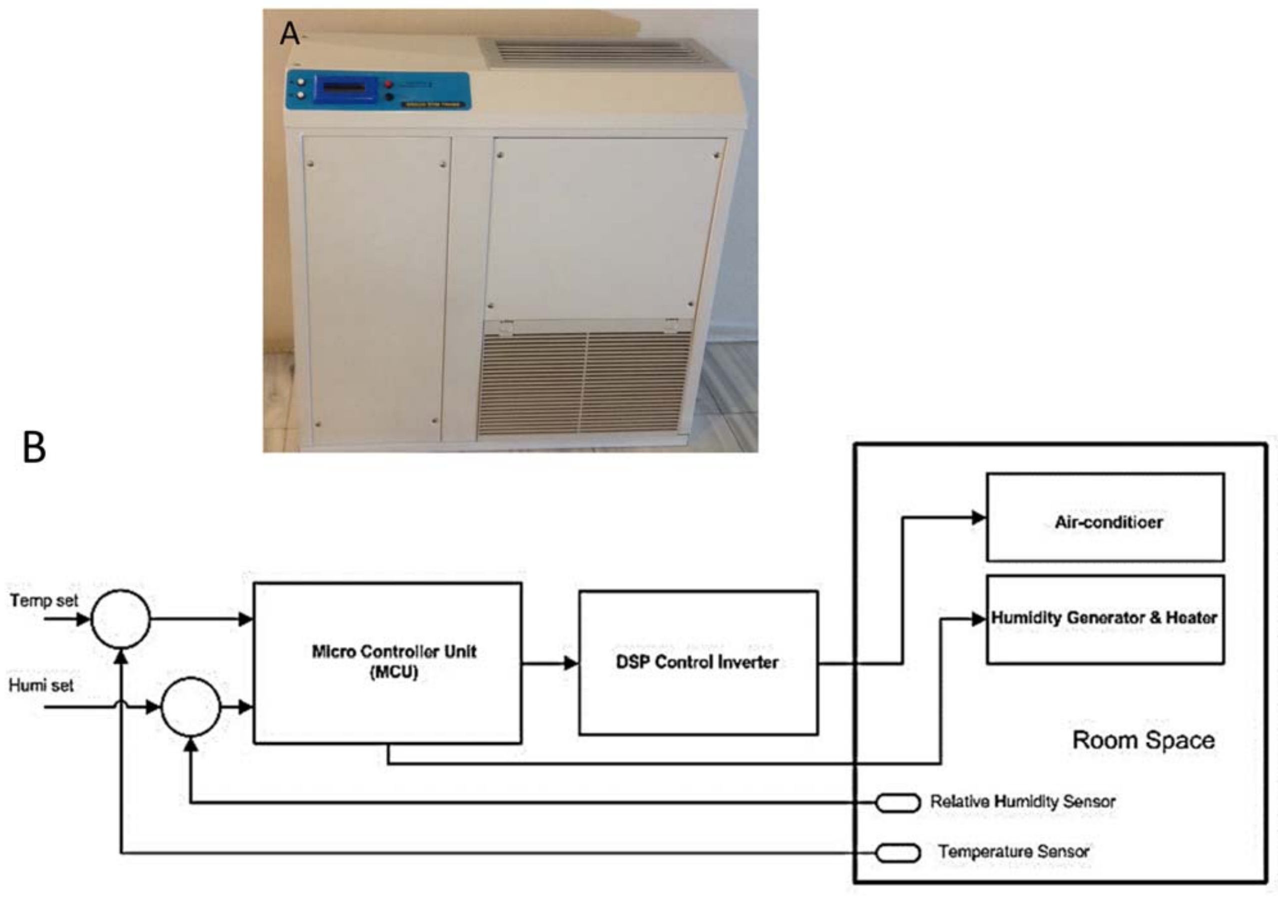

Figure 2. The newly invented temperature and humidity control machine (A). Diagram demonstrating the operation system of the machine with the air condition (B).

portable dehumidifiers in reducing the levels of dust mite allergens.[11,12] Since RH is temperature dependent, we believe that the clinical improvements associated with the use of our machine is due to its ability to maintain stable RH in conjunction with stable temperature which is achieved through air-conditioning and its microprocessor-based control.[7] Previous studies have demonstrated that maintaining daily indoor relative humidity below 50% RH but allowing RH above 50% for more than 2 hours daily resulted in dust mite's population growth.[13] As a result, a portable dehumidifier in home use may not be able to control the dust mite population due to its inability to maintain stable temperature and RH on a 24 hours basis.

After installing the temperature and humidity control machine, we observed a modest but significant improvement in total nasal symptom score as early as 2 months after installation, but this observation did not correlate with the levels of dust mite allergen. Previous studies have recommended decreasing the level of Der p 1 and Der f 1 below 2 µg per gram of dust in order to lower the risk of dust mite sensitization.[14] Exposure to 10 µg of Der p 1 and Der f 1 per gram dust has been suggested as an exposure threshold for the development of asthma symptoms in already sensitized children.[15] In the present study, the levels of Der p 1 and Der f 1 from the bedrooms of the participating patients before machine installation varied from 0.2 to 4 µg per gram of dust but three out of seven subjects exposed to dust mite allergen had levels of Der f 1 and Der p 1 already below 2 µg per gram of dust before the start of the experiment which may have resulted in the poor correlation reported. In addition, 40% of the participating patients had mild but persistent symptoms. The apparent efficacy of the machine in reducing TNSS may be stronger if there were more severe patients enrolled. For instance, objective measurements such as rhinomanometry or nasal peak flow were not evaluated in the present study. We believe that improvement in these objective measurements if investigated may be demonstrated earlier than the changes of clinical symptoms and may help better assess the benefits associated with the use of our machine. Furthermore, evidence of long-lasting improvements of clinical symptoms may have been demonstrated if the machine was used for a longer duration.

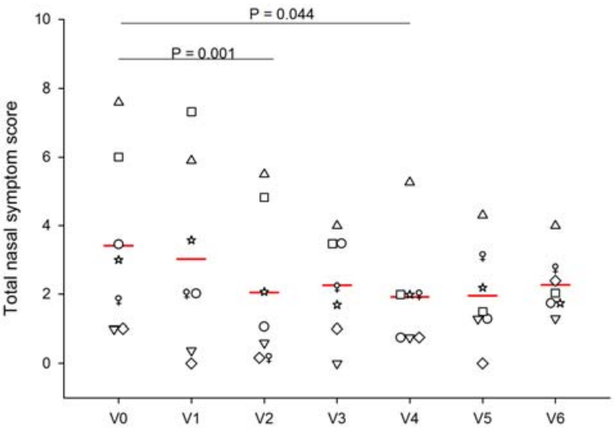

Figure 3. Clinical symptom score in each visit after machine installation. V0=before machine installation, V1,2,3,4,5, and 6 represent 1, 2, 3, 4, 5 and 6 months after installation respectively. Line represents median and same symbol represents data from same subject.

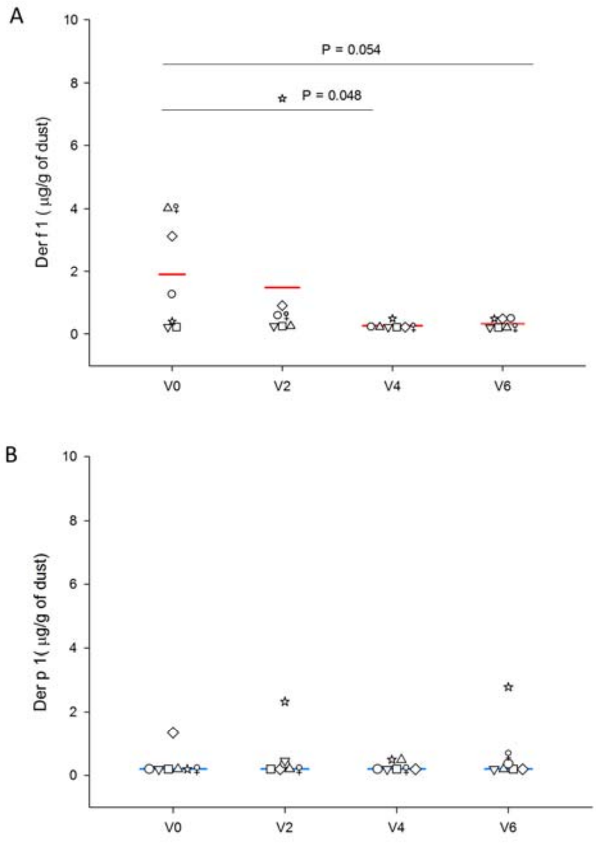

Figure 4. The level of house dust mite allergen Der f 1 (A) and Der p 1 (B) in each visit after machine installation. V0=before machine installation, V2, 4, 6 represent 2, 4 and 6 months after installation respectively. Line represents median and same symbol represents data from same subject.

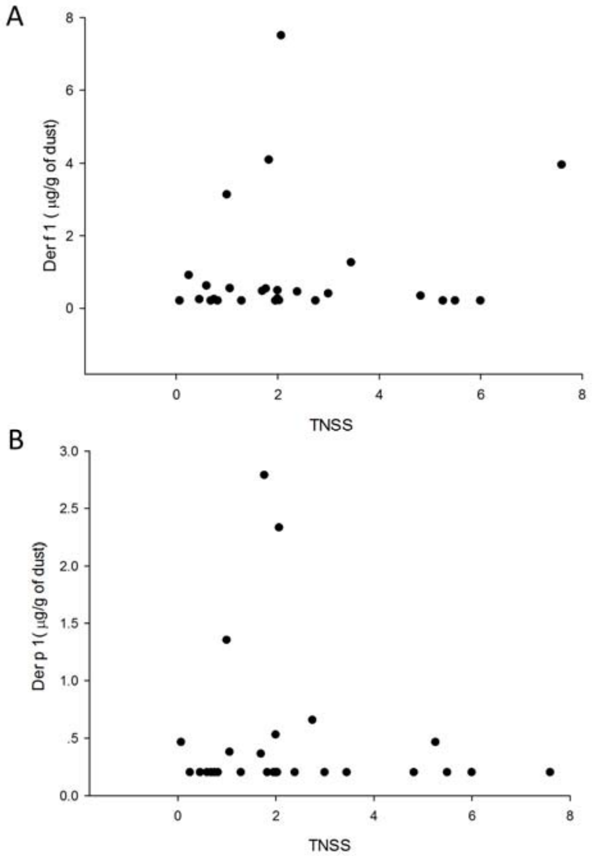

Figure 5. The level of house dust mite allergen Der f 1 (A) and Der p 1 (B) and total nasal symptom score.

One of the overarching limitations of the present study is that this novel machine is not commercially available and currently under-developed. Consequently, there were limited numbers of machines available for our research to be conducted which resulted in a small number of enrolled patients. In addition the short duration of the experiment did not allow us to capture the influence of seasonal variation on mite proliferation and allergens which can hide important elements of interpretation. Nevertheless, we believe there are enough pieces of evidence to suggest that our machine can be considered as a promising tool to improve our ability to control room temperature and humidity in a clinical setting [7] and as such, we believe that seasonal variation should only have minimal influence on RH. Additionally, there were no control patients in the present study and hence the placebo effect cannot be excluded as an explanatory factor for the improvement of the clinical symptoms we observed. Finally, other methods that can control or decrease levels of dust mite allergens were not monitored in the present study and consequently further studies are required to assess the efficacy of our machine in a more integrative way. In particular, studies involving more participating patients, implemented over longer period of time and including non-intervention/control groups will be valuable to improve our appreciation of the efficacy of our proposed methodology.

In conclusion, this pilot study has demonstrated that the novel temperature and humidity control machine was able to decrease the level of dust mite allergen in the bedroom of dust mite sensitized AR children. There was also a modest improvement in clinical symptoms of AR. Larger sample size and controlled studies are required to confirm the efficacy of this machine.

Acknowledgments

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