

EFFECT OF THE ALLERGIC INFLAMMATORY DISEASE IN THE UPPER
RESPIRATORY TRACT TO THE COGNITIVE FUNCTIONS AND THE
PHYSICAL PERFORMANCE

Ph.D. thesis

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1. INTRODUCTION

1.1. EFFICIENCY OF THE "RHINOLIGHT" PHOTOTHERAPY WITH NASAL PROVOCATION TEST

1.1.1. About allergic inflammatory disease in the upper respiratory tract

The allergic rhinitis is an IgE-mediated allergic inflammation of the nasal mucosa which is one of the most common chronic diseases with a prevalence of 20% in developed countries. Its frequency is increasing according to data of WHO (2-3% per year), by 2050 it could affect up to 50% of the population in developed countries. In Hungary there are 3 million patients with allergies, their number has doubled in the past 20 years. The development of allergic rhinitis is determined by a combination of genetic and environmental factors, and significant familial recurrence. Symptoms are triggered by seasonal or perennial allergens that cause persistent or intermittent complaints. Classic symptoms are sneezing, itching, rhinorrhea and nasal congestion, which interfere with sleep, concentration in learning and working, and leisure activities. Several well-known and frequently used methods of treating allergic rhinitis are used. Avoiding allergens is effective, but often not fully feasible (eg. ragweed, weed). The basic drug therapy is antihistamines and local nasal steroids, additionally cromolyns, anticholinergics and leukotriene antagonists can be considered. As a sole cause of treatment, we have good experiences with sublingual immunotherapy.

1.1.2. Diagnosis of allergic rhinitis

An allergy questionnaire for distinguishing between rhinitis and allergic rhinitis can also be used in family practice. In the diagnosis of allergic rhinitis, the first step is to complete a simple allergy questionnaire. Based on the 5 yes and 5 no responses, allergic rhinitis can be suspected and allergy tests are recommended. Skin test with inhaled allergen is inexpensive, reproducible and provides immediate response. It is not possible to administer antihistamines in the treatment of systemic steroid therapy and localized skin lesions. As a second line test, from serum anti-allergic antibody (IgE specific) can be detected (ELISA, RAST). If the skin test and/or spec. IgE results and clinical symptoms are not consistent, allergen-specific nasal

provocation (NP) can be performed, which in the case of a positive response causes typical allergic symptoms (rhinorrhea, nasal congestion, itching, lacrimation). The effect of NP on a variety of allergen-sensitive patient groups has been studied already (dust mite, cat hair). In seasonal allergic rhinitis, the temporal association of the development of upper respiratory symptoms with the seasonal increase in circulating IgE specific antibodies against the allergen (eg. ragweed), provides further evidence that systemic manifestations are pathophysiological factors of the disease.

1.1.3. Rhinolight photo therapy

UV radiation was used to treat immuneproliferative disorders at the beginning of the 19th century when Finsen cured lupus vulgaris (skin tuberculosis) with phototherapy. Since then, photo therapy has been successfully used in many ways in dermatology, such as atopic dermatitis and numerous skin diseases. The mechanism of UV therapy is based on eosinophilic and T-cell apoptosis and histamine degranulation replacement. The Szeged RL team demonstrated first that the use of (mUV / VIS) Rhinolight therapy in the treatment of allergic rhinitis resulted in a significant improvement in total nasal symptoms (TNS). In the study, individual scores were significantly lower than the baseline in sneezing, rhinorrhea and pruritis, but nasal congestion was not affected by the therapy. 90% of the clinical symptoms were improved by endonasal phototherapy, both in intermittent and persistent rhinitis.

1.2. PHYSICAL AND COGNITIVE PERFORMANCE OF PATIENTS WITH RAGWEED ALLERGY

1.2.1. Allergy affects on cognitive functions

There are also a limited number of studies on the effect of allergic symptoms on cognitive functions often providing conflicting results. Some of these studies have found no changes in certain cognitive functions, such as verbal and visual memory, the speed of information processing, and attention processes between healthy people and people with allergy. Allergy symptoms together initiate biochemical changes that have a direct effect on the function of the central nervous system. In addition, some authors suggest that it is the antihistamine used for

the treatment of allergy that causes cognitive function deficits, whereas other studies suggest that antihistamine treatments decrease vigilance.

1.2.2. Physical performance

The relevant literature according to the correlation between sports and allergy shows that physical exercise improves the symptoms of allergic rhinitis, including the decrease in nasal blockage as a characteristic improvement. In addition, sports, such as longdistance running or swimming, may not only decrease airway resistance but also improve endurance and lung capacity. A large number of studies on the effect of sports on cognitive functions have found that regular physical exercise has a beneficial effect on nervous system functions, thus on a range of cognitive functions including attention, executive functions, short-term memory, decision-making, and locomotor functions.

1.3. EXPLICIT AND IMPLICIT MEMORY OF PHYSICALLY ACTIVE AND INACTIVE PATIENTS WITH RAGWEED ALLERGY

1.3.1. Explicit and implicit memory

Explicit and implicit memory function was examined in several patient groups already. For instance, in amnesic patients the severe damage of explicit memory was demonstrated by „multiple-choice” questionnaire, however, in the research of implicit memory task; „the weather prediction”, they performed just as well as the healthy control group. Csábi et al. examined the explicit and implicit systems involvement in children with sleep-related breathing disorders. The involved children provided lower explicit memory performance compared to the control group, although the implicit learning process remained intact. Thus dissociation was found between the involvement of the two types of memory system in the case of children with and without sleep disorders.

2. AIMS OF THE THESIS

2.1. EFFICIENCY OF THE "RHINOLIGHT" PHOTOTHERAPY AFTER NASAL PROVOCATION TEST

A recurring therapeutic question is whether treatment prior to seasonal pollen release is suitable for preventing the onset of the symptoms. Allergen-specific NP is a well known clinical method to detect allergic sensitization that can not be clearly determined by the prick test and spec-IgE methods. The changes of nasal air flow (NIPF, rhinomanometry and/or acoustic rhinometry) and symptoms triggered by nasal application of a standard amount of the examined allergen, are recorded.

2.2. PHYSICAL AND COGNITIVE PERFORMANCE OF PATIENTS WITH RAGWEED ALLERGY

Despite the high prevalence of hay fever, no study has so far assessed the effect of symptoms on cognitive functions and physical performance together. This study aims to investigate the acute allergic effects of allergic rhinitis on respiratory parameters, fitness, and cognitive functions. Does regular sport activity modify the influencing effect of allergic symptoms induced by single acute allergen exposure on respiratory, cognitive, and physical outcomes?

2.3. EXPLICIT AND IMPLICIT MEMORY OF PHYSICALLY ACTIVE AND INACTIVE PATIENTS WITH RAGWEED ALLERGY

The purpose of this study is to explore the effects of allergic rhinitis on the function of different memory systems. Whether regular sport influence the functioning of cognitive abilities and the effect of allergic symptoms on the quality of life?

3. MATERIALS AND METHODS

3.1. EFFICIENCY OF THE "RHINOLIGHT" PHOTOTHERAPY AFTER NASAL PROVOCATION TEST

3.1.1. Participants

In the study, 24 patients participated with allergy rhinitis caused by ragweed, of which 12 received intranasal phototherapy (Rhinolight phototherapy: mUV/VIS RL group), to the 12 patient in the control group was administered placebo.

3.1.2. Procedure

The tests were measured at the Department of Oto-Rhino-Laryngology and Head-Neck Surgery of the University of Szeged. The participants participated in the study had moderate/severe symptoms of ragweed allergy in season, which was confirmed by detectable specific IgE in blood or prick skin tests. In each case, two examinations (visit 1 (V1) and visit 2 (V2)) were carried out in ragweed pollen-free period, with nine days between the two measurements. Initially, basic measurements (M0) were made on both occasions, then nasal respiratory function was measured 10 minutes (NP-M10), 30 minutes (NP-M30) and 8 hours (late) after NP, and we registered symptoms based on total nasal symptoms score (TNS) and total symptom score (TSS). During the NP, nasal mucosa of test subjects was stimulated with 0.2 ml of 30 IR/ml ragweed allergen per each side.

3.1.3. Intranasal phototherapy

In the RL group, both nose mucous membranes were treated 4 times with the mixture of ultraviolet and visible light (mUV/VIS) between the two measurement times. The starting dose was 1.6 J/cm^2 , the dose was increased by 0.25 J/cm^2 each time, giving a fourth dose of 2.6 J/cm^2 . The duration of a treatment is 3 minutes. Radiation is wide, high spectrum (Rhinolight Ltd, Szeged, Hungary, 180 mW, composition of 5% UVB, 25% UVA and 70% visible light). The placebo group received low intensity visible light therapy.

3.1.4. Nasal respiratory function tests

These studies are suitable for the objective assessment of nasal breathing, NP-specific objective evaluation. We measured nasal volume with acoustic rhinometry (AR) between 0-7 cm³ and 2.2-5.4 cm³ from the nasal inlet (GM Instruments, UK). During the examination of the Nasal Inspiratory Peak Flow (NIPF), the maximum inhaled air flow was measured [L/min], providing information on both nasal nodes at the same time (Clement Clarke, UK).

3.1.5. Measurement of nasal and total symptom score

After each measurement, patients immediately filled out a symptomatic diary. The symptom points are subjectively assessed to evaluate the strength of the individual symptoms, which is rated by the patient on a scale of 0 to 3, where 0 means asymptomatic. The total nasal symptom score (TNS) refers to sneezing, rhinorrhea, nasal congestion and itchy nose, with a maximum score of 12 points. The total symptom score (TSS) includes, besides the above mentioned, itching throat, itching eyes and coughing, with a possible maximum score of 21 points.

3.2. PHYSICAL AND COGNITIVE PERFORMANCE OF PATIENTS WITH RAGWEED ALLERGY

3.2.1. Participants and procedure

We enrolled 35 participants in the study but due to unpleasant symptoms, several of them did not able to complete the tests after NP. Finally, a total of 14 subjects with ragweed allergy including five women and nine men completed the whole examination and their results were analyzed. The group of athletes consisted of seven subjects who did regular training at least five times (7.5 h) a week. The control group also consisted of seven untrained subjects. The two groups were matched in age and level of education (paired-sample t-test analysis). The subjects involved in the study had allergic rhinitis confirmed by specific immunoglobulin IgE or prick test and showed moderate to medium symptoms to ragweed in the allergy season. Each participant was tested on two occasions; first at baseline with no symptoms and then, on a second session, immediately after allergen-specific nasal

provocation. Nasal provocation was performed using ragweed allergen (Stallergenes, France) at a dose of 0.2 ml of 30 IR/ml for each nostril. Both sessions took around 90 minutes for each subject, and respiratory functions were measured first, followed by neuropsychological functions and finally fitness indicators.

3.2.2. Assessment of respiratory functions

Acoustic rhinometry (AR) (GM Instruments, UK) is an objective measurement based on the sound reflection of the nasal cavity. It is a static type of respiratory function test to assess nasal cavity volumes in the range of 0–7 cm³ (AR vol. 0–7) and 2–5 cm³ (AR vol. 2–5) from the nostrils. Dynamic respiratory function tests included NIPF (L/min) measurement (Clement Clarke, UK). Lung volume and its changes compared with time [forced expiratory volume in 1 s – FEV1 (L)] and airflow [peak inspiratory flow – PIF (L/s)] were monitored by spirometry (Thor Laboratories, Hungary). From the test values, we could infer the width or stenosis of the airways.

3.2.3. Assessment of fitness index

The Harvard step test (HST), a relatively well-known test in this area, was used for the objective assessment of physical fitness. The test involved the subject stepping up and down a platform at a rate of 120 steps/minute for 5 min. After this exercise had been completed, the subject's pulse rate was measured at 1–1.5, 2–2.5, and 3–3.5 min. The fitness index was calculated using the following equation: time of exercise in seconds \times 100/sum of pulses \times 2. Guiding values are summarized in a standard table.

3.2.4. Assessment of cognitive functions

To map the neuropsychological functions of the brain, we used tests that covered all of its function areas and were able to indicate minor alterations. Executive functions were assessed using letter and semantic fluency tests, where the participant had to list as many words as possible either beginning with a specified letter (letter fluency) or from a specified category (semantic fluency) in 60 s. In our experiment, in the case of letter fluency, we used letter “t” before the provocation and letter “k” after the provocation. In case of semantic

fluency, we used “animal” category before the provocation and “food products” category after the treatment. We measured the number of correct words, the perseverations, and errors both in letter and semantic fluency tasks. The verbal component of short-term memory was tested using a digit span test, in which the subjects had to repeat a growing list of numbers in a predefined order. Complex working memory capacity was measured by a backward digit span, in which subjects again had to repeat an increasing list of numbers, but this time in reverse order. Each digit span test consisted of four series and the subjects had to repeat at least two of them correctly to proceed to the next span. The shortest span consisted of three items, the longest contained nine items, and only the correctly repeated ones were accepted. The short-term verbal and complex memory capacity of the subject was defined as the longest span that the subject could repeat correctly. The visual component of the short-term memory was tested using a Corsi block-tapping test, which involves tapping 2-cm-diameter cubes randomly fixed on a black board in the sequence shown by the researcher. Each span consisted of four series and the subject had to repeat at least two of them correctly to proceed to the next span. The shortest span consisted of three items, the longest contained nine items, and only the correctly repeated ones were accepted. The short-term visual span of the subject was defined as the longest span that the subject could repeat correctly. The level of anxiety was assessed using Spielberger’s State-Trait Anxiety Inventory (STAI) that measures the level of both state anxiety and trait anxiety. The subjects had to assess on a scale of 1–4 how each statement characterizes them.

3.3. EXPLICIT AND IMPLICIT MEMORY OF PHYSICALLY ACTIVE AND INACTIVE PATIENTS WITH RAGWEED ALLERGY

3.3.1. Participants

The study started with 35 participants, but due to the unpleasant symptoms many of them did not complete the nasal post-provocation measurement. Eventually 14, ragweed-allergic patient has completed all the tests, of whom five were women and nine men. In the study seven athlete and as a control group seven non-sportmen participated, all of them are allergic to ragweed.

3.3.2. Procedure

The tests were carried out at the University of Szeged's Oto-Rhino- Laryngology and Head- Neck Surgery Department. The persons involved in the study were allergic to ragweed by seasonal moderate/severe symptoms, which were demonstrated by bloodtest specific IgE or skin prick tests. Each participant was tested twice, a week passed between the two measurements. The first measurement was the baseline measurement in a ragweed-free period. During the NP both nostril's nasal mucosa of the test subjects were stimulated with 0.2 ml 30 IR/ml dose of ragweed allergen (Stallergenes, France).

3.3.3. Tasks

3.3.3.1. Measurement of the explicit memory

We used subtests of the Rivermead Behavioural Memory Test, as immediate and delayed story recall, in order to measure explicit memory. During the assignment, the investigator reads a story that the test person must recall immediately, then after a predetermined time of delay must recall again. The story contains 21 thoughts, and the verbatim recall of each unit is worth a point, while the recall of the content is half a point. During the two surveys, we used different stories to avoid learning effects.

3.3.3.2. Measurement of the implicit memory

In order to measure implicit memory, we used the Alternating Serial Reaction Time Task (ASRT), which is suitable for simultaneous measurement of general skill and sequence-specific learning. During the task the test subjects had to react as fast and accurate as possible, to visual stimuli appearing in one of the four empty circles on the computer screen, with the help of a special keyboard designed for this purpose. After pressing the corresponding key, the next stimulus appeared 120 ms later. In both session the test subjects completed 20 blocks.

3.3.3.3. Criteria for evaluating the Alternating Serial Reaction Time task

During the ASRT-task the elements of the specified sequence alternate with random elements (ie: 2r1r4r3r), however some of the triple stimuli (so called: TRIPLET) occurred

more frequently, than others. For example the 2_1, 1_4, 4_3, or the 3_2 are more frequent triplets, because the third element could be part of the sequence but could be random element as well. In contrast, the 1_2 or 4_1 triplets are less frequent, because the third element can only be random. Based on previous literature the more frequently occurring triplets are called high frequency triplets, the less common triple stimuli are called low frequency triplets. Of the 64 possibility, 16 is high frequency triplet which occurred in 62.5% during the task, thus can be more predictable, than the 48 low frequency triplet, which occurred in 37.5%. Based on previous literature the test subjects became faster with high, than with low frequency triplets, which we call as sequence-specific learning. The type of acceleration on solving the task, which is independent of the type of triplet is called general skill learning. Thus, this task is enable us to measure both in separately these two aspects of implicit learning at the same time.

During the statistic analysis of the ASRT-task, we classified the 20 blocks was grouped five times which are called EPOCH, so we received a total of four epochs. In the course of the analysis in case of accuracy was avaraged, while the reaction time was calculated by median, and only the proportion of correct answers were taken into account. These were analyzed separately for both high and low frequency epochs. Based on previous studies, we have select two types of stimuli triplets in the analysis: the repetitions (ie: 222, 333) and the trills (ie: 212, 313).

4. RESULTS AND DISCUSSION

4.1. EFFICIENCY OF THE "RHINOLIGHT" PHOTOTHERAPY AFTER NASAL PROVOCATION TEST

During our investigations, we were investigated the effect of phototherapy on the symptoms of single-, high-dose, sudden and intense nasal reactions in ragweed allergic patients. For this purpose, patients with intranasal RL phototherapy and untreated allergic patients were compared. Based on our results there was no difference between the two groups in the initial parameters. After NP, significant symptomatic worsening was observed in both groups compared to the M0 period. NP induced nasal congestion, sneezing, rhinorrhea,

itching nose (TNS), and itching throat, itchy, watery eyes and coughing (TSS). The volume of nasal cavity and the parameters' of nasal airflow significantly reduced to NP-M10 and NP-M30, then in the eight-hour period's measurement the symptoms gradually retracted. After the second provocation (V2), similar results were obtained.

NP results increase of eosinophils in the tissues, increases the rapid growth of Th2 cytokines in the cells, and increases Th2 transcription factors in T cells. The growth of T cells in the nasal mucosa is high compared to healthy individuals due to the excessive response of Th2. In the IgE-sensitized individuals, after a sudden allergen release, within minutes, symptoms such as sneezing and itching nose appear, that are usually followed by rhinorrhea and nasal congestion, and within 1 hour the symptoms are reduced. These reactions are derived from the complexes of crosslinked and sensitized IgE allergen, on the surface of mast cells and basophils resulting in the release of histamine and tryptase.

Phototherapy was used to reduce single high dose allergen-induced symptoms. Based on our results, among the placebo and the RL group there was no difference between the measured values during the repeated provocation after the (mUV/VIS) Rhinolight therapy. The Szeged RL Group reports in a number of articles on the efficacy off RL phototherapy treatment in allergic rhinitis. However, recent studies have been conducted in ragweed allergic season, which means significantly smaller but sustained allergen exposure. There was no late reaction after the NP in our study.

4.2. PHYSICAL AND COGNITIVE PERFORMANCE OF PATIENTS WITH RAGWEED ALLERGY

The aim of this study was to assess the effects of allergic rhinitis on respiration parameters, fitness and cognitive functions, and also to see whether regular exercise helps develop resistance against the symptoms. To address these questions we compared the performance of athletes to non-athletes. The results show a significant difference in fitness indicators and lung capacity between the group of athletes with allergy and the allergic control group before NP. The athletes performed better in the fitness test and showed higher lung capacity values than the control group. Following NP, the athletes also showed significantly better lung capacity and fitness indicator values than the control group. In terms

of cognitive functions, the only significant difference was measured in the performance of the complex working memory with higher scores seen in the group of athletes.

Our results show that the allergic athletes scored higher for fitness indicators and lung capacity in both assessment sessions, which is probably explained by the fact that they are in better physical condition. The two groups showed no differences in cognitive functions before NP.

No decline in performance was found in either group following NP, which are in line with studies that also found no differences in cognitive functions with or without allergic symptoms. Our results are in contrast with previous research that indicated a decline in the performance of people with allergy in reaction time, short-term memory performance and divided attention tasks. However, these studies compared the performance of healthy controls to the performance of those with allergy. The differences in methodology may also account for our different results.

The two measuring sessions unsurprisingly revealed a difference in the level of nasal cavity restriction when the two groups were individually compared. NP led to blockage in the nasal cavity, which restricted respiration, but provocation caused no decline in lung capacity. In some studies, patients with allergic rhinitis seemed to be free from bronchial hyperresponsiveness, but signs of allergic inflammation were found in the airways in the form of sputum induction.

Our results suggest that the allergic athlete group performed better compared to both the control and to itself following NP in executive functions and complex working memory tests. This may be explained by findings from previous studies, which have shown that regular exercise correlates with resilience, thus improves stress resistance. This is why people doing regular exercise tend to perform better under stress. This study involved athletes who are exposed to stress regularly during preparation for international competitions and during competitions themselves. Adaptation to such stress may explain the improved physical and cognitive performance following NP compared to baseline.

4.3. EXPLICIT AND IMPLICIT MEMORY OF PHYSICALLY ACTIVE AND INACTIVE PATIENTS WITH RAGWEED ALLERGY

During our investigation, we were looking for how allergic rhinitis affects the explicit and implicit memory, and investigate if regular sports influence explicit and implicit memory? In order to do that, we compared allergic athletes with allergic persons who do not sports. There is no such study in the literature, which studied memory factors for allergic rhinitis athletes. The only similar study was to research the quality of life of athletes suffering from hayfever, with the help of „Quality of Life” questionnaire, and they concluded the beneficial effect on allergic symptoms of the nasal spray called Budesonide.

Based on our results, the athlete and the control group performed similarly in the asymptomatic period, including tests of explicit and implicit memory. However, athletes achieved better results in post-provocation measurement regarding explicit memory on immediate and delayed memory recall tests. Our test results confirmed the results of Fletcher et al., who demonstrated at Olympic athletes that stressors influence psychical factors - such as positive personality, motivation, and confidence - to the extent that they significantly contribute to achieving optimal sports performance. In another study, examining university students, it was found that physical activity has a significantly good effect on mental health and interacts with the level of trait anxiety. The relationship between resilience, mental health and sport performance was observed in athletes with the help of the Connor-Davidson Resilience Scale, and they concluded that the level of resilience could „predict” sport performance and mental health. These three studies proved, that doing sports regularly is related to the resilience level, thus increasing the resistance to stress, which can be developed with positive psychological factors, adequate mental health, and in team sports with positive conformity. Therefore, those who do sports on a regular basis, are more likely to be able to perform well, under greater pressure, as well. Our results, however, are contrary to those studies where it has been shown that stress did not affect or impaired explicit memory performance.

The allergic group of athletes achieved better results compared to itself as a result of provocation in explicit memory, but there was no change in the measurement of implicit memory compared with baseline measurements. Our results contradict previous studies where

performance deterioration was found in patients with explicit memory performance. However, our findings confirm the results of the same studies where no deviation was found in the implicit memory function. According to Hartgerink-Lutgens et al. allergic patients only experience subjective degradation, but this deterioration does not appear on objective tests.

In the control group, there was no change in the performance of explicit or implicit memory after the provocation compared to the asymptomatic period.

5. CONCLUSIONS

5.1. EFFICIENCY OF THE "RHINOLIGHT" PHOTOTHERAPY AFTER NASAL PROVOCATION

High dose allergen exposure means "over-threshold stimulus". As a result, cytokine outflow reaches such a level, which can not be compensated for by the administered dose RL phototherapy's eosinophil and T cell apoptosis and histamine degranulatory inhibitor effect. There was no late reaction after the NP in our study.

The aim of our study is to investigate whether (mUV/VIS) phototherapy is suitable for preventive treatment, if it has preventive effect. It has been shown that phototherapy did not produce significant effects on symptoms caused by a single-, high-dose allergen on the non-inflamed nasal mucosa. So far, (mUV/VIS) light therapy has not yet been used for prevention, only for therapeutic purposes. Based on the results of our research, the use of phototherapy does not encourage the use as prophylaxis. Additional quantitative studies are required to determine the therapeutic threshold.

5.2. PHYSICAL AND COGNITIVE PERFORMANCE OF PATIENTS WITH RAGWEED ALLERGY

In summary, NP did not influence significantly the cognitive and physical performance of the control group of people with allergy and the group of allergic athletes, in fact, improved results were recorded for certain functions. Disturbing elements caused by NP, such as swollen nasal mucosa, sneezing and watering eyes did not hinder cognitive functions in

people with allergy. One explanation may be the competitive spirit of athletes. In sum, this study indicates that exposure to a single, high dose of allergen may result in increased focus in patients with allergy.

5.3. EXPLICIT AND IMPLICIT MEMORY OF PHYSICALLY ACTIVE AND INACTIVE PATIENTS WITH RAGWEED ALLERGY

NP with a single high dose allergen causes serious allergic symptoms in patients with sensitized allergens, which may result in an increased concentration on the athletes. Nasal symptoms caused by provocation, such as nasal congestion, rhinorrhea, sneezing, and lachrymation did not impair memory functions. The improvement of increased explicit functions that can be observed in athletes point to a high level of concentration potential in a stressed state.