



The effect of steady state exercise on circulating human IgE and IgG in young healthy volunteers with known allergy

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Abstract

Allergy prevalence in the general population has been increasing since the 1980s and there is increasing evidence of a higher incidence of allergy or asthma in elite athletes. For individuals suffering from allergy to airborne allergens, such as pollen, exercise may exacerbate their condition due to increased ventilation during exercise. The effect of an acute steady state moderate intensity exercise task on circulating immunoglobulin E was therefore assessed in volunteers with known allergy. Immunoglobulin concentrations were assessed in young healthy volunteers with allergy ($n = 14$) and control non-allergic volunteers ($n = 7$) pre- and post- an acute steady state moderate intensity exercise task (60% W_{max} for 40 min). Airborne allergic volunteers ($n = 7$) displayed increased IgE levels (31% increase) ($p < 0.01$) but food allergic volunteers ($n = 7$) showed decreased IgE levels, following exercise (53% decrease) ($p < 0.01$). There was no significant change in IgG levels in volunteers with food or airborne allergy or in control volunteers in response to exercise. Acute steady state moderate exercise significantly altered circulating IgE concentrations in volunteers with known allergy, while IgE concentrations in non-allergy sufferers did not change. © 2008 Sports Medicine Australia. Published by Elsevier Ltd. All rights reserved.

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1. Introduction

Allergy prevalence in the general population has been increasing since the 1980s regardless of gender, age or racial background. In the UK, 25% of adults suffer from an allergy. Asthma and allergy often also represent important problems for individuals undertaking exercise as the incidence of exercise-induced asthma (EIA) and exercise-induced bronchoconstriction (EIB) has also been seen to increase. In addition, several studies have reported higher incidence of allergy or asthma in elite athletes.^{1–3} For those individuals suffering from allergy to airborne allergens, such as pollen, exercise may exacerbate their condition due to increased ventilation during exercise. Further, several food allergies can be accompanied by asthma and if food allergy is present in childhood, it can be a predictor of adult asthma.⁴ The incidence of food allergy has also increased in recent years and may

be mediated by immunoglobulin E (IgE) or may be non-IgE mediated. The most common food allergies which account for 90% of all food allergic reactions are milk, eggs, peanut, tree nuts, fish, shellfish, soy and wheat.

Research assessing the incidence and severity of EIA and EIB is well documented,⁵ and it is widely accepted that exercise is accompanied by a redistribution in the population of immune cells and in some cases the activation of an inflammatory response. However, research into the effects of exercise on immunoglobulin levels and perhaps more relevant in allergy, the effect of exercise on IgE, is extremely limited. Studies have shown that IgE levels in sinus lavage, plasma and IgE positive blood cells are higher in allergy sufferers compared to allergy free controls.⁶ Nehlsen-Cannarella et al.⁷ assessed immunoglobulin concentrations (IgG, IgA and IgM) in serum from healthy women after moderate exercise for 45 min, but more recent literature is sparse. Interestingly, it has been observed that psychological stress has caused an increase in IgE levels in patients with atopic dermatitis, an inflammatory skin disease with an IgE-dependent

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Table 1

Subject characteristics, where appropriate values shown are mean $\pm$ S.D.

Group	Sex	Age (years)	Body mass (kg)	VO ₂ (ml/kg/min)
Control	M = 4, F = 3	20.1 $\pm$ 1.8	71.8 $\pm$ 11	55.0 $\pm$ 9.7
Airborne allergy	M = 4, F = 3	21.5 $\pm$ 2.7	68.8 $\pm$ 7.4	52.1 $\pm$ 6.4
Food allergy	M = 3, F = 4	20.8 $\pm$ 2.5	69.3 $\pm$ 9.1	53.2 $\pm$ 8.5

allergic response.⁸ Many similarities have been drawn between psychological stress and physical stress when assessing the response of hormones or hormone-dependent factors or when considering the immune response, hence it is possible that physical stress such as exercise may stimulate a response in immunoglobulin concentrations which may differ between allergy sufferers and non-allergy sufferers. This study assessed the effect of a moderate intensity, steady state bout of acute exercise on circulating IgE concentrations in healthy young adults with known allergy and non-allergic controls.

2. Methods

21 normo-tensive, non-obese volunteers (14 with allergies: 7 volunteers had a food allergy; 7 volunteers had an allergy to an airborne allergen and 7 controls) from the University of Birmingham, UK participated in this study after giving written consent. A breakdown of subject characteristics can be seen in Table 1. The volunteers' characteristics were not significantly different between the groups. The allergy volunteers were asked to state their known allergy and confirmation of diagnosis was sought from the diagnosing immunologist. Examples of food allergens were garlic, eggs, shell fish and examples of airborne allergy were cat hair, pollen and dust mite. The protocol was approved by the Ethics Committee of the University of Birmingham. All volunteers fasted for 4 h prior to the experiment.

An incremental test to exhaustion was completed by each subject on an electromagnetically braked cycle ergometer (Lode Excalibur Sport, Groningen, Netherlands) to determine the individual maximum power output ($W_{\max}$) and maximal oxygen uptake (VO_{2max} in ml/kg/min). An initial work load was set at 60 W with 35 W increments every 3 min. Expired air samples were collected via a mouthpiece during the last 30 s of each 3 min stage of the graded exercise test into previously evacuated Douglas bags (Cranlea, Birmingham, UK). Samples of expired air were analysed for fractions of O₂ and CO₂ by using a Servomex 1400B4 analyser (Sussex, UK). The analyser was calibrated prior to each test using certified reference gases (100% nitrogen; 15.1% O₂, 5.0% CO₂ and 17.2% O₂, 2.0% CO₂, BOC Gases, Surrey, UK). The volume of expired air was measured using a Harvard dry-gas meter (Harvard Apparatus, Edenbridge, Kent, UK).

Heart rate (HR) was monitored continuously and recorded every 3 min by a radiotelemetry HR monitor (Polar Vantage NV, Kempele, Finland). $W_{\max}$ was calculated from the last completed work rate, plus the fraction of time spent in the

final non-completed work rate multiplied by the work rate increment.

Volunteers returned to the lab once again in a fasted state. A blood sample was taken using venepuncture in the supine position (5 ml) and then 40 min of exercise was completed on the ergometer at 60% of the volunteers' $W_{\max}$. Further blood samples (all taken in the supine position) were taken immediately after exercise (volunteers were asked to come off the bike immediately upon exercise cessation) and 1 h post-exercise. Volunteers were not allowed to consume fluid during the tests until the final blood sample had been taken.

All blood samples were collected into EDTA tubes (K3, BD, Plymouth, UK) and stored on ice until centrifugation at 3500 rpm for 10 min at 4 °C. After centrifugation, aliquots of the plasma were stored and frozen at –80 °C until further analysis. Total plasma protein concentration was determined by the method of Smith et al.⁹ Immunoglobulins were assessed by commercially available ELISA (DRG Ltd., Germany).

Data were checked for normality, homogeneity of variance and sphericity before statistical analysis. Data were analysed using a two-factor (trial $\times$ time) repeated measures ANOVA with post hoc Tukey tests. Statistical significance was accepted at $p < 0.05$. All ELISA analyses were undertaken in triplicate, and values are expressed as mean values and standard deviation (mean $\pm$ S.D.). An intra- and inter-batch coefficient of variation of 3.2% and 8% respectively for the IgE ELISA was observed and 4.2% and 11% respectively for the IgG ELISA.

3. Results

Of the 21 volunteers recruited for this study, all adhered to all phases of testing in the study. Total plasma protein concentrations were not significantly different between groups (control 76.9 $\pm$ 7.2 mg/ml; airborne allergy 81.7 $\pm$ 8.1 mg/ml, and food allergy 85.4 $\pm$ 10.1 mg/ml). IgE levels increased immediately after exercise in volunteers with airborne allergies (31% increase) ($p < 0.01$), with levels returning to baseline 1 h after exercise (Fig. 1). IgE levels in volunteers with food allergies decreased immediately following exercise (53% decrease) ($p < 0.01$), and remained constant at this level up to 1 h after exercise (Fig. 1). IgE levels in control volunteers remained constant throughout the whole time course, and were significantly lower than the allergy groups ($p = 0.045$) (Fig. 1). The final blood sample taken post-exercise + 1 was taken in only 15 volunteers.

Table 2

Immunoglobulin G concentration in plasma of volunteers in response to steady state exercise.

	IgG pre-exercise (mg/ml)	IgG post-exercise (mg/ml)	IgG post-exercise + 1 h (mg/ml)
Control	15.0 ± 2.0	16.2 ± 1.6	15.0 ± 1.12
Airborne allergy	13.6 ± 0.82	14.0 ± 1.24	13.2 ± 0.9
Food allergy	12.7 ± 1.0	15.6 ± 1.58	15.1 ± 1.8

Values shown are mean ± S.D.

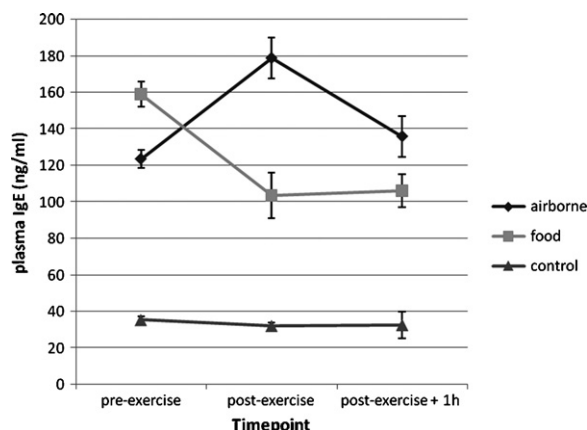


Fig. 1. Circulating plasma IgE levels in young healthy subjects. Data plotted in subject groups (food allergies, airborne allergies and controls) at three timepoints (pre- post- and post-exercise + 1 h). Exercise task was steady state bout for 40 min at 60% W_{max} . Values are mean ± S.D.

There was a significant interaction effect between time (pre- and post-) and the two allergy groups ($p=0.011$).

There was no significant change in IgG levels in volunteers with food or airborne allergy or in control volunteers following exercise (results shown in Table 2).

4. Discussion

40 min of exercise at 60% W_{max} had a significant, immediate effect on immunoglobulin E in volunteers with known allergy. IgE levels decreased in volunteers with food allergies after moderate intensity exercise but increased in volunteers with airborne allergies. IgE levels are often raised in allergy¹⁰ and within this study, IgE levels in volunteers with known allergy were significantly higher, not only at baseline but throughout the test, when compared to non-allergic controls. The observed response of IgE to exercise in volunteers with airborne allergy was not unexpected, as increased ventilation rates stimulated by exercise may increase the possibility of antigen stimulation through greater than normal quantities of microorganisms entering the body and through the breakdown of natural mucosal immunity by drying of airway secretions.¹¹ In addition, serum IgE levels are associated with airway responsiveness in asthma sufferers.¹² However the decrease in IgE seen in volunteers with food allergy is more difficult to rationalise.

Exercise stimulates a redistribution of blood flow, and as a consequence perfusion of some organ systems is

also altered.¹³ For example the vessels perfusing the lungs undergo a vasodilatation to allow greater oxygen exchange, whereas the vessels supplying the gastrointestinal tract undergo vasoconstriction.¹⁴ As a result, IgE produced by tissue specific cells in these regions may display altered circulating levels due to this altered regional perfusion. It may also be noted that IgG, where no changes in level were observed, is primarily produced in systemically distributed plasma cells.

Acute exercise may stimulate a change in blood volume, a haemoconcentration, which may account for some observed increase in haemoglobin, red blood cell number, and plasma protein concentration.¹⁵ Although few studies actually measure blood volume, it is possible to estimate both blood and plasma volume changes induced by exercise using measurements of haematocrit and haemoglobin concentration.¹⁶ A limitation of this study is that measures of blood volume were not taken, however the results show IgE increases and decreases, which appear to be dependent on the nature of volunteers' allergy. If the changes were to be explained by transient haemoconcentration then all values would be expected to increase.

5. Conclusion

In this study significantly altered circulating IgE levels in young healthy allergic volunteers were observed following a bout of acute steady state exercise. It should be noted that the IgE measured in this study was not specific for the allergens that the individuals were known to respond to. Response was altered between volunteers who had known allergy to airborne allergens and volunteers with food allergy. Increased IgE in airborne allergic volunteers was not unexpected, as discussed earlier. However decreased IgE levels in volunteers with food allergy may prove an interesting finding. Currently avoidance of the known allergen is used as the best therapy or treatment for food allergy, although a number of new therapies are under investigation. Further studies using exercise, perhaps investigating regularity, intensity and reaction to known allergen following exercise are required to investigate whether exercise has any effect on the allergen specific response.

Practical implications

- Allergy sufferers have increased levels of allergen specific proteins in their blood.

- New therapies are being considered in the treatment of food allergy, and exercise should be considered as a way to reduce the levels of allergen specific protein in the blood of individuals with food allergy.
- Individuals with allergy to an airborne allergen, such as pollen, may increase the possibility of antigen stimulation when exercising, due to increased ventilation rates stimulated by exercise.

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