SHORT COMMUNICATION

Immunological responses to training in conditioned runners

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Summary

1. We measured the concentrations of leucocyte subpopulations, immunoglobulins and complement in six well-conditioned runners before and after a typical 8-mile (12·8 km) training run at 70–75% of $\dot{V}O_2$ max.

2. Before running all components were within the normal range. Exercise failed to produce a significant rise in neutrophils. There was also no change in immunoglobulins or complement concentrations immediately or 24 h after exercise. Lymphocyte subpopulations were also unchanged except for a progressive rise in antibody-dependent cytotoxic effector cells (K-lymphocytes).

3. These results suggest chronic exercise training has no apparent adverse effect on circulating cellular or humoral immune components in healthy subjects. An increase in K-lymphocytes may provide added host defence capacity during periods of stress, although the mechanism of increase is unexplained.

Key words: cellular immunity, exercise, stress leucocytosis.

Abbreviations: E, erythrocyte antigen of Rhesus blood-group system; EAC, erythrocyte antibody complement; EA, ovalbumin.

Introduction

The long-term effects of intense daily physical training on immune system components and the corresponding host defence status of athletes is unknown. This subject is of clinical interest because of the possible interaction between chronic physical training and susceptibility to, or complications from, various infectious diseases. The purpose of this study is to describe the responses of major circulating immune components to a typical training run in well-conditioned distance runners.

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Methods

Subjects

Six male runners (ages 27–40 years) volunteered with informed consent to serve as subjects. Each subject trained 6–10 miles daily. The average maximum oxygen consumption ($\dot{V}O_2$ max.) was 65·8 ml of O_2 STP min^{-1} kg^{-1} body wt.

Protocol

Studies were conducted in morning hours (07.00–09.00 hours) during cool weather. Each subject ran a continuous 8-mile course on level pavement at an average velocity of 13 km/h and estimated work intensity of 72% of $\dot{V}O_2$ max. [$\dot{V}O_2$ was estimated from average running velocity (m/min): $\dot{V}O_2$ (ml STP min^{-1} kg^{-1} body wt.) = 0·178 (m/min − 150) + 33·3].

Peripheral venous blood samples were drawn by antecubital venepuncture 15 min before exercise, 10 min and 24 h after exercise.

Analytical techniques

Total leucocyte and differential counts. These were determined by standard procedures.

Mononuclear cells. These were isolated by the method of Boyum (1968) as described by

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Flaherty, Surfus, Chmelik, Bryan, Dickie, Reed & Rankin (1976).

Lymphocyte subpopulations. These were determined from characteristic E (T-lymphocytes), EAC (mouse) (B-lymphocytes) and EA–IgG rosette formations by the method of Mendes, Tolnai, Silveira, Gilbertsen & Metzgar (1973).

Non-specific antibody-dependent cytotoxicity. This cytotoxicity of EA–IgG rosette mononuclear cells was measured by two assays *in vitro*. In one assay, mononuclear cells were incubated with heterologous antibody-sensitized ^{51}Cr-labelled chicken erythrocytes as described by Flaherty, Martin, Storms, Kritz, Surfus & Reed (1977). In the second assay, mononuclear cells were mixed with heterologous antibody-coated ^{51}Cr-labelled human Chang liver cells as described by Ziegler & Henney (1976). The effector cells for this assay are killer lymphocytes (K-lymphocytes) (Perlman, 1976).

Total immunoglobulins. IgG, IgA and IgM concentrations were determined by using commercially available Tri-Partigen Kits (Behring Diagnostics).

Total IgG levels. These were determined by radioimmunoassay with the Pharmacia Phadebas Kit.

Complements (C_3 and C_4). These were determined by the commercially available kits and standards obtained from Behring Diagnostics.

Results

Before exercise total leucocyte count, subpopulations of leucocytes, immunoglobulin and complement levels were within normal limits (Table 1).

Immediately (10 min) after exercise there was a non-significant rise in total leucocytes which included variable increases in mature neutrophils, T-lymphocytes (E rosettes), B-lymphocytes (EAC rosettes) and mononuclear EA–IgG rosettes. The antibody-dependent cytotoxic activity of K-lymphocytes was significantly increased when measured in the Chang liver-cell assay.

At 24 h postexercise all cellular populations were within the pre-exercise range. However, the cytotoxic activity of K-lymphocytes remained significantly increased.

There was no significant change in immunoglobulin or complement levels at 10 min or 24 h postexercise.

Discussion

Previous studies of acute exercise have consistently reported an increase in circulating leucocytes that is proportional to the intensity and duration of work (Garry & Bryan, 1935; Ahlborg, 1968). The leucocytosis has been attributed to a selective

TABLE 1. *Summary of immune responses to exercise*

Values are means ± SD.

Response	Rest	Postexercise	
		+10 min	+24 h
Component leucocytes (mm^{-3})			
Total leucocytes	5373 ± 1995	7166 ± 2569	4996 ± 1889
Neutrophils	3046 ± 1385	3930 ± 854	2667 ± 788
Bands	62 ± 111	10 ± 24	64 ± 59
Eosinophils	118 ± 46	105 ± 138	71 ± 99
Basophils	11 ± 27	35 ± 45	23 ± 28
T-Lymphocytes	1361 ± 554	1690 ± 1047	1390 ± 609
B-Lymphocytes	446 ± 236	557 ± 565	434 ± 217
EA-IgG rosettes	228 ± 318	658 ± 978	254 ± 193
Antibody dependent cytotoxic activity (%)			
K-Lymphocytes	67 ± 10	79 ± 14*	83 ± 12*
Mononuclear cells	35 ± 9	41 ± 11	41 ± 10
Immunoglobulins (i.u.)			
IgG	148 ± 29	151 ± 32	146 ± 28
IgA	128 ± 48	131 ± 43	122 ± 48
IgM	134 ± 69	180 ± 52	173 ± 32
IgE	296 ± 381	315 ± 326	224 ± 272
Complement (mg/100 ml)			
C_3	83 ± 10	92 ± 14	96 ± 13
C_4	27 ± 7	28 ± 6	28 ± 7

* $P < 0.05$ compared with the resting value (Student's paired *t*-test).

mobilization of mature neutrophilic granulocytes from marginated pools located in postcapillary venules. The mobilization is thought to be mediated by a combination of haemodynamic redistribution and increased secretion of catecholamines and cortisol (Athens, Haab, Robb, Meuer, Ashenbrucker, Cartwright & Wintrobe, 1961).

In the present study we detected only small and statistically non-significant increases in neutrophils immediately after prolonged submaximum exercise. Several studies have reported a diminution of exercise leucocytosis in endurance-trained athletes (Garry & Bryan, 1935). Our data also suggest the magnitude of granulocyte response to exercise is reduced by endurance training.

The normal increase in secretion of catecholamines and cortisol during prolonged exercise is slightly reduced by physical training (Hartley, Mason, Hogan, Jones, Kotchen, Mougey, Wherry, Pennington & Rockets, 1972; White, Ismail & Bottoms, 1976). Moorthy & Zimmerman (1978) measured leucocyte responses to a 32-km road race and found the magnitude of leucocytosis was proportional to increases in serum cortisol. However, the leucocyte rise was least in the most highly trained runners.

Mobilization of leucocytes during exercise is effectively abolished by β-adrenoreceptor blockade (Ahlborg & Ahlborg, 1970). Chronic exercise training could produce a decrease in neutrophil β-adrenoreceptors similar to that observed in normal subjects treated with β-adrenoreceptor agonists (Galant, Duriseti, Underwood, & Insel, 1978). However, a more recent study of β-adrenergic function *in vitro* showed normal responsiveness in granulocytes obtained from distance runners before and after exercise (Busse, Wilson, Hanson & Folts, 1980).

Our finding of increased K-lymphocyte cytotoxic activity after exercise are in agreement with Hedfors, Holm & Ohnell (1976). The mechanism for the selective mobilization of K-lymphocytes is unknown but may be related to increased lymph flow and redistribution during exercise. These cells may play a pivotal role in the termination of viral infections so an increase in their circulating density could provide an enhanced non-specific immune response to a viral infection.

The circulating concentrations of immunoglobulins and complement were unaffected by exercise in our subjects. We would assume that any uniform increases or decreases of these proteins might be produced by exercise-induced intravascular fluid shifts. Changes in individual immunoglobulin components or complement levels could occur with increased losses due to catabolism or immune reactions. However, no changes occurred. These findings generally agree with previous studies reporting no alterations in immunoglobulins or complement during 2 weeks of daily intensive physical training (Eberhardt, 1971).

In summary, our studies show a remarkable stability of cellular and humoral immune components during and after training runs in healthy endurance athletes. These findings argue against any transient alteration of host defences due to decreased concentrations of circulating phagocytes, immunocytes, immunoglobulins or complement. Chronic exercise training appears to attenuate the mobilization of neutrophils that usually occurs with physical activity. The observed increase in K-lymphocytes after prolonged exercise may be a non-specific response. However, these cells could also provide added capacity for host defence during and after physical stress.

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