

Original article

EXERCISE-INDUCED LEUCOCYTOSIS IN SOME HEALTHY ADULT NIGERIANS

N. O. SODIQUE¹, O. ENYIKWOLA^{1*} AND A. U. EKANEM²

¹Department of Human Physiology and ²Department of Human Anatomy,
College of Medical Sciences, University of Maiduguri, Maiduguri, Nigeria.

SUMMARY

The effect of exercise on circulating leucocytes with regards to changes in total and differential counts was studied in 25 adult Nigerians of both sexes. All subjects exercised on a bicycle ergometer till exhaustion. A significant ($p < 0.001$) leucocytosis occurred immediately after the exercise with the predominant increase being lymphocytes. There was significant ($p < 0.01$) eosinopenia and neutropenia in females. Basophilopenia was however significant ($p < 0.01$) in the males but not in females. A significant ($p < 0.01$) post-exercise monocytopenia was observed in the females but not in the males. This study demonstrates a marked leucocytosis due to lymphocytosis, and a decrease in the number of granulocytes and monocytes. The post-exercise lymphocytosis observed may be due to increased secretion of catecholamines, decreased adherence of leucocytes to the endothelium and massive influx of lymphocytes into the circulation from the lymphatic vessels.

RESUME

L'effet de l'exercice physique sur les globules blanc circulant dans le sang vis a vis de la variation de leur quantite' totale et de leur pourcentage etait etudie chez 25 adultes Nigerians des deux sexes. Tous les patients s'exercaient sur une bicycelette ergometrique jusqu'a l'epuisement. Un delicie significatif ($P < 0.001$) en leucocytes apparaissait immediatement apres reduction en oesinophiles et neutrophiles chez les femmes. Une reduction en basophiles etait cepedant significative ($P < 0.001$) chez les Hommes mais pas chez les femmes. Une reduction significative ($P < 0.001$) en monocytes etait dservee chez les femmes mais pas chez les Hommes. cette etude demontre une neduction accentuee de globules blancs (leucocytes) due a la uduction deslymphocyte et une neduction du nombre de granulocytes et de monocytes. La reduction du nombre de globules blancs apres l' exercice physique pourrait etre due a l'augmentation en secretion de catecholamines et a la reduction d' adherence des leucocytes a l'endothelium et a l' afflux massif des lymphocytes en circulation dans les vaisseaux lymphatiques.

The basal level of circulating white blood cells in man can be rapidly and substantially increased with physical activity (Andersen, 1955; Ahlberg, 1967; McCarthy *et al.*, 1987). In most studies, it has been found that short term exercise (less than 30 minutes) leads to a lymphocytosis and a neutropenia (McCarthy and Dale, 1988); although there are a few reports of brief periods (usually less than five minutes) of very intense exercise causing an immediate decrease in leucocyte or neutrophil numbers, particularly in highly trained athletes (Andersen, 1955). The similar lymphocytosis which occurs early on during long term exercise has usually been found to subside later, leaving a predominant neutrophilia (see Garrey and Bryan, 1935). The reports in the literature have dealt mostly with the effect of exercise in Caucasians. Ezeilo (1972) reported some differences in the haematological values in Caucasians and Africans. This investigation assesses the comparative effect of a brief, severe muscular exercise in an African (Nigerian) population.

MATERIALS AND METHODS

Twenty-five students of the University of Maiduguri volunteered for this study. Their ages ranged from 17 to 28 years, with a mean of 22.5 \pm 3.4 years. All were physically inactive, i. e., had no formal exercise programme for 12 months. Apart from absence of symptoms, pregnancy or current medication, physical fitness and apparent good health constituted the criteria for inclusion in the study. Each student volunteered with informed consent to participate in the exercise.

Experimental protocol

The experiments were conducted under laboratory conditions, temperature ranging from 34EC to 36EC. Each subject exercised to exhaustion on a bicycle ergometer at a work load maintained at 1.5 kg for the males and 1.0 kg for the females. Exhaustion was defined as the inability to maintain the required pedal frequency.

Following Andersen (1955) the subjects came to the laboratory in a post-absorptive state on the testing day. After resting at least 20 minutes, pre-exercise blood (2.5 ml) was drawn from a cubital vein with minimum of stasis. Immediately after exercise, a blood sample was drawn in a similar way.

White blood cell count and differential leucocyte counts were performed for each subject before and after exercise using the method described by Moore (1958).

* Author for correspondence

Statistical analysis

Except where indicated, results are presented as means " standard errors of means. Differences between means were assessed using paired Student's *t*-tests.

RESULTS

The post-exercise total leucocyte counts showed a significant ($p < 0.01$) increase over the pre-exercise values in all subjects (Table 1). In the females, the percentage increase averaged 32.4% as against 22.8% in males. The percentage increase in total leucocyte count immediately after the exercise in all subjects averaged 26.1% (Table 1). The pre-exercise total leucocyte count in males was significantly ($p < 0.01$) higher than in females (Table 1).

Table 1.
Effect of exercise on total leucocyte count in some apparently healthy Nigerians

Group	Duration (min.)	Total leucocyte count (cells/mm ³ " SEM)	
		Pre-exercise	Post-exercise
Females (n = 10)	4 - 6	6405 " 592	8500 " 827*
Males (n = 15)	5 - 7	8617 " 424	10585 " 611**
Males and females (n = 25)	4 - 7	7732 " 406	9752 " 526***

* 32.7% increase, $p < 0.001$; ** 22.8% increase, $p < 0.01$; *** 26.1%, $p < 0.01$.
All levels of significance were determined using Student's *t*-test.

Table 2.
Effect of exercise on differential leucocyte count in some apparently healthy Nigerians

Group	Differential leucocyte count (% of total \pm S.D)									
	Neutrophils		Eosinophils		Lymphocytes		Basophils		Monocytes	
	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise	Pre-exercise	Post-exercise
Females n = 10	24.0 \pm 4.4	19.0 \pm 2.4	4.0 \pm 0.6	2.4 \pm 0.6	54.0 \pm 4.4	72.0 \pm 2.3	5.0 \pm 1.5	1.9 \pm 0.6	14.0 \pm 1.2	8.0 \pm 0.7
	-21%, $P < 0.01$		-40%, $P < 0.10$		+25%, $P < 0.001$		-52%, $P < 0.10$		-43%, $P < 0.01$	
Males n = 15	24.0 \pm 2.1	19.0 \pm 2.2	4.0 \pm 0.6	2.0 \pm 0.4	64.0 \pm 2.2	77.0 \pm 2.9	2.9 \pm 0.3	0.9 \pm 0.3	8.0 \pm 0.3	5.0 \pm 1.3
	-20.8%, $P > 0.01$		-50% $P < 0.05$		-16.9%, $P < 0.001$		-68.9%, $P < 0.01$		-37.5%, $P < 0.01$ *	
Males + Females n = 25	24.0 \pm 2.1	19.0 \pm 1.6	4.0 \pm 0.4	2.1 \pm 0.4	60.0 \pm 2.4	75.0 \pm 2.0	4.0 \pm 0.7	1.3 \pm 0.3	10.0 \pm 1.1	1.8 \pm 1.2
	-20.8%, $P < 0.01$		-47.5%, $P < 0.01$		-20%, $P < 0.001$		-76.9%, $P < 0.01$		-40%, $P < 0.01$	

Statistical levels of significance were determined using Student's *t*-test. *Not significant.

Neutropenia at significant levels was observed (Table 2) immediately after the exercise in females ($p < 0.01$), in the pooled category ($p < 0.01$) but not in the males ($p < 0.01$). There was marked eosinopenia in all subjects after the exercise (Table 2). A significant ($p < 0.001$) lymphocytosis also occurred immediately after the exercise (Table 2). The differential lymphocyte count significantly appreciated from 54.0 " 4.4 to 72.0 " 2.3 in females ($p < 0.001$); 64.0 " 2.2 to 77.0 " 2.9 in males ($p < 0.001$) and in the pooled category from 60.0 " 2.4 to 75.0 " 2.0 ($p < 0.001$). Basophilopenia was significantly ($p < 0.01$) observed in the males (Table 2). However, monocytopenia significantly

occurred ($p < 0.01$) in females and in the pooled category only (Table 2).

DISCUSSION

It has been shown that active participation in a short bout of muscular exercise caused marked leucocytosis with the predominant increase being lymphocytes (Tables 1 and 2). This relates to the findings of Andersen (1955), Masuhara *et al.* (1987) and Sodique (1997) that short bouts of physical exercise on a bicycle ergometer massively increased leucocyte counts in both trained and untrained athletes.

The leucocytosis caused by exercise in this study could be due to a number of factors. These would include the actions of catecholamines, cortisol, demargination, neuronal transmitters and peptides or purine chemical transmitters (see McCarthy and Dale, 1988). A possible explanation for the post-exercise increase in leucocyte count is that large numbers of cells which at rest, are adherent to the walls of blood vessels (endothelium), i. e., marginated pool, are suddenly washed into circulation (Morehouse and Miller, 1976). This is called demargination and results in massive increase in the number of leucocytes in the circulating pool. The demargination is due to the force of increased volume and velocity of blood flow (Morehouse and Miller, 1976). Demargination could also be due to the effects of stress hormones, such as adrenaline, which decreases the adherence of leucocytes to the endothelium via interaction with β -receptors on both cell types (Gleeson, 1995).

In brief exercise (<1 hour), as in this study, only the effects of catecholamines in increasing the ratio of circulating to non-circulating cells, as well as that of demargination will be evident (McCarthy and Dale, 1988). The effect of cortisol can only be observed much later as a delayed increase in the total number of leucocytes in the vascular compartment (Keast *et al.*, 1988). Catecholamines have indeed been shown to modify both the number and function of circulating lymphocytes (Keast *et al.*, 1988). Some of the effects of adrenaline on the sub-populations of circulating leucocyte, may be sequential in nature, with a predominant and immediate rise in lymphocytes (Keast *et al.*, 1988) as seen in this study (Table 2), followed by a neutrophilia after about 30 minutes (Keast *et al.*, 1988). It has been suggested that the lymphocytosis, due to the action of adrenaline, may result from increased emptying of lymph into the blood stream through the thoracic duct (Keast *et al.*, 1988).

Stress of any sort (including exercise, as in the present study) results in an increased secretion of hormones of the adrenal cortex and one of the results produced by the actions of these hormones is a decrease in the number of eosinophils in the blood (Morehouse and Miller, 1976). As the exercise undergone in this study, however, was brief, the eosinopenia observed is unlikely to be essentially due to the effect of the hormones of the adrenal cortex - specifically cortisol, which are released over a longer duration of exercise, but rather a relative decrease due to the marked lymphocytosis. This explanation may also be applicable to the observed basophilopenia and monocytopenia. Both basophilopenia and monocytopenia are normal physiological effects of cortisol on white blood cells (McCarthy and Dale, 1988), but in this study, are probably relative decreases due to the marked lymphocytosis.

The neutropenia observed was dependent on the severity and duration of the exercise. Because the exercise was hard and vigorous, the active muscles (skeletal) underwent anaerobic respiration. This resulted in the accumulation of lactic acid in the muscles. Lactic acid in the muscles irritates them and acts as a stimulus similar to inflammation. As neutrophils are the first line of defence (Guyton, 1991), they leave the vascular compartment by diapedesis and move into the tissues, in the direction of the source of the stimulus by chemotaxis. This accounts for the neutropenia observed.

Leucocytosis due to exercise occurring in males and females was not significantly different (Tables 1 and 2). This lends weight to the statement that 'femaleness' and 'maleness', in relation to exercise seem to be more of a matter of morphology than physiology (Morehouse and Miller, 1976).

REFERENCES

- Ahlborg, B. (1967).** Leucocytosis in blood during prolonged physical exercise. *Forsvarsmedicin* **3**: 36 - 48.
- Andersen, K. L. (1955).** Leucocyte response to brief, severe exercise. *J. Applied Physiol.* **7**: 671 - 674.
- Ezeilo, G. C. (1972).** Haematological values in pregnant Zambian women. *Trop. Geogr. Med.* **24**: 152 - 156.
- Garrey, W. E. and Bryan, W. R. (1935).** Variations in white blood cell counts. *Physiol. Rev.* **15**: 597 - 638.
- Gleeson, N. (1995).** Exercise and immune function. *Science News and Views* **4**: 8 - 9.
- Guyton, A. C. (1991).** In: *Textbook of Human Physiology*, pp. 365 - 371. 8th ed., W. B. Saunders Company, Harcourt Brace Jovanovich Inc., Philadelphia.
- Keast, D., Cameron, K. and Morton, A. R. (1988).** Exercise and the immune response. *Sports Medicine* **5**: 248 - 267.
- Masuhara, M., Kami, K., Umobayana, K. and Tatsumi, N. (1987).** Influences of exercise on leucocyte count and size. *J. Sports Medicine* **27**: 285 - 290.
- McCarthy, D. A. and Dale, M. M. (1988).** The leucocytosis of exercise. *Sports Medicine* **6**: 333 - 363.
- McCarthy, D. A., Perry, J. D., Melson, R. D. and Dale, M. M. (1987).** Leucocytosis induced by exercise. *Brit. Med. J.* **295**: 636.
- Moore, R. (1958).** The white blood cell count in the indigenous people of East Africa. *J. Trop. Med. Hyg.* **61**: 70 - 72.
- Morehouse, L. E. and Miller Jnr., A. T. (1976).** In: *Physiology of Exercise*. pp. 180, 224, 330, 334. 7th ed. C. V. Mosby Company, Saint Louis .
- Sodique, N. C. (1997).** Effect of hard (short-term) exercise on total and differential leucocyte counts in some apparently healthy Nigerians. B. Sc. Dissertation, University of

Maiduguri, Maiduguri, Nigeria.

Received: January 23, 2000

Accepted: July 14 2000

