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Immune response to changes in training intensity and duration in male athletes

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ABSTRACT

The aim of the present study was to compare the effects of exercise at 85% VO2max (30min) with prolonged exercise at a lower work rate (60% VO2max for up to1.5 h) on blood leukocyte count and the percent blood leukocyte subsets in young men athletes. Fifteen athlete male university students (mean ± SD age 22.3±2.6 yr, weight 65.5±5. 72 Kg and height 174.2±3.64 cm) participated in this study. After physical examinations, subjects performed Running on an electrically treadmill at 85% VO2max (30 min). On another occasion, separated by at least one week, subjects performed exercise on the same treadmill at 60% VO2max for 1.5 hour. Blood samples were collected from a peripheral arm vein before and immediately after exercise sessions, and served for determination of total and differential leukocyte counts. The acquired data were analyzed by MedCalc software and using t-tests. Statistical significance was set at $P < 0.05$. Both exercise bouts caused significant ($p<0.05$) elevations of the blood leukocyte count. Mean blood leukocyte count were increased from 6.4±0.79 to10.26±3.3 and 6.32±0.75 to 9.85±2 ($\times 10^6$/ml) after exercise at the 60% VO2max (1.5 h) and 85% VO2max (30min) respectively. After exercise at the lower work rate for a longer duration, blood monocytes (1.25%) and neutrophil percent (11%) were significantly higher and blood lymphocytes (11.75%) were significantly lower than those observed at 80% VO2max. However, No significant differences were observed in the blood monocytes percent after the both exercise bouts ($p<0.05$). The results showed that when exercise is very prolonged, the diminution of innate immune function is greater, than or at least as great as that observed after fatiguing exercise at higher work rates. The sum of acute responses observed in this study may exert a protective effect against sickness and may be used to improve health and lifespan in athletes.

Key words: leukocyte count, leukocyte subsets, exercise intensity, male athletes.

INTRODUCTION

The interrelationships between exercise and immune function have been widely studied since the first publications on exercise-induced leukocytosis [10]. This is an important area of study because exercise may modulate the immune system's ability to monitor and protect the individual from disease and to repair damage [15]. Exercise intensity, duration and frequency, and individual levels of physical fitness are important factors in determining immune response to physical effort [16]. However, the magnitude of the leukocytosis is apparently related to the intensity and duration of exercise and seems to be most pronounced after strenuous endurance exercise [10]. Exercise may stimulate or lower immune function. Regular exercise performed at moderate intensity is commonly associated with increased immune resistance against infections [8]. On the other hand, strenuous exercise has been associated with transitory immune suppression, potentially increasing susceptibility to infections, especially upper respiratory infections. [16]. Glucocorticoids and catecholamines are released during exercise and stimulate leukocyte chemotaxis, adhesion, phagocytosis and antigens presentation [21, 23]. Numerous studies have established that intensive endurance exercise (70–85% VO_2max) induces a biphasic perturbation of the circulating leukocyte count [18]. Many clinical-physical stressors such as surgery, trauma, burns and sepsis induce a pattern of hormonal and immunological response similar to that of exercise. Specific changes that have been observed, both following strenuous exercise and in infectious disease states, include: the acute phase response, leukocyte mobilization and activation, release of inflammatory mediators (cytokines), tissue damage and cell infiltration, the production of free radicals and activation of the complement, coagulation and fibrinolytic pathways [19]. It has thus been suggested that heavy exercise might be used to cause graded and well-defined amounts of muscle trauma, thereby serving as an experimental model for inflammation and sepsis [19] obviously, the responses to ethically acceptable doses of exercise are much smaller than those seen in sepsis. Therefore, in order to obtain readily measured changes, it is important to choose a pattern of activity that maximizes disturbances in immune function. In the present study, we compared changes in circulating white cell count and subsets, in young men athletes after performance of two different endurance exercise (exercise at 85% VO2max (30min) and prolonged exercise at a lower work rate (60% VO2max for up to1.5 h)).

MATERIALS AND METHODS

Fifteen athlete male university students participated in this study. The inclusion criteria were age between 20-30 years, being non-smoker, and VO_{2max} more than 45 ml/kg/min. They were informed of the purpose, nature and possible side effects involved in the study. Prior to participating, subjects read and signed an informed consent form and completed a physical activity and health readiness questionnaire that was previously approved by the researchers and pervious investigators experiences [22]. The initial two-hour session included a medical examination (which excluded those with recent infection and allergic conditions) and tests of maximal aerobic power (VO_{2max}). Physical measurements (height, body mass and skinfolds) were also completed at this visit. The VO_{2max} was determined using a standard incremental treadmill protocol. The treadmill exercise protocol was completed on a Quinton 3.0 treadmill (Quinton. Club track, model: 3.0, USA). Measurement of body composition was obtained prior to test using the three-site skin-fold caliper method [3]. The measurements were performed in the

Physiological Studies Center of Mohaghegh Ardebili University (43% relative humidity with a environmental temperature of 25 centigrade). No medication or nutritional supplements were allowed the last week before or throughout the study period. High-intensity exercise was not allowed during the last 2 days before trials, and no exercise was permitted the last day before each trial. A dietary record was obtained for the last 24 h before the first trial, and the subjects were instructed to consume an identical diet the day before each subsequent trial. After physical examinations, subjects performed Running on an electrically treadmill at 85% VO2max (30 min). On another occasion, separated by at least one week, subjects performed exercise on the same treadmill at 60% VO2max for 1.5 hour. Blood samples were collected from a peripheral arm vein before and immediately after exercise sessions, and served for determination of total and differential leukocyte counts. The total number of leukocytes, neutrophils and lymphocytes were analyzed on a Sysmex K 1000 cell counter (Toa Medical Electronics, Kobe, Japan). All parameters were adjusted for blood volume changes, using the Dill and Costill method [2]. The heart rate was monitored continuously throughout each of the two sessions, using a Sport-Tester®. The oxygen consumption was also measured intermittently during the two types of aerobic exercise, using the SensorMedics Metabolic Cart. Volunteers were encouraged to drink water during and following all experimental conditions.

Statistical Analysis

Results are expressed as means ± SD, and $P<0.05$ was considered statistically significant. As in other small-sample studies on relatively homogenous populations, a normal distribution of data was assumed. Changes in leukocyte and subsets were analyzed by MedCalc software and using t-tests.

RESULTS

Subjects' physical and physiological characteristics and %Fat are presented in Table1. Also, descriptive data for blood leukocyte count and the percent blood leukocyte subsets values in subjects presented in Table 2. Both exercise bouts caused significant ($p<0.05$) elevations of the blood leukocyte count. Mean blood leukocyte count were increased from 6.4±0.79 to10.26±3.3 and 6.32±0.75 to 9.85±2 ($\times10^6$ cells/ml) after exercise at the 60% VO2max (90 min) and 85% VO2max (30min) respectively (Figure 1). After exercise at the lower work rate for a longer duration, blood monocytes (1.25%) and neutrophil percent (11%) were significantly higher and blood lymphocytes (11.75%) were significantly lower than those observed at 80% VO2max (Figure 2). However, No significant differences were observed in the blood monocytes percent after the both exercise bouts ($p<0.05$).

Table1. Individual Characteristics of subjects

Variable	Mean ± SD.
Age (yrs)	22.3±2.26
Height (cm)	174.2±3.64
Weight (kg)	65.5±5.72
BMI(kg/m^2)	21.61±1.95
Body fat (%)	10.7±5.1
VO2max ($ml.kg^{-1}.min^{-1}$)	55.63±9.04
HR max ($beats.\ min^{-1}$)	197±4

Table2. Descriptive findings of blood leukocyte count and the percent blood leukocyte subsets values of subjects before and after the two training program

Variable	***60% VO2max (90 min)***		***85% VO2max (30 min)***	
	Pre test	*post test*	*Pre test*	*post test*
Leukocyte count x 10^9 cells/liter	6.4±0.796	10.2± 3.3	6.32±0.75	**9.85±2**
Lymphocytes percent	37.58±4.62	29.3±10.05	37.16±6.19	**41.5±5.19**
Monocytes percent	5.83±1.26	6.08±1.44	7.16±0.93	**6.16±1.52**
Neutrophil percent	53.58±5.28	63.5±11.2	51±6.64	**49.9±5.8**

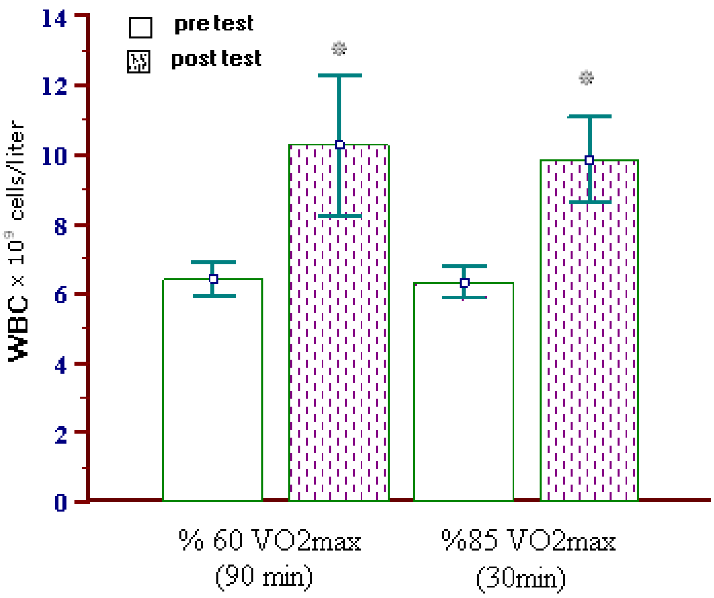

Figure1. Blood leukocyte count changes in two exercise program. Values represent means ± SD (n=15). * Values indicate both exercise bouts caused significant elevations of the blood leukocyte count (p<0.05).

DISCUSSION

In order to explore which type of strenuous exercise provides the most useful model of the inflammatory process, we compared the acute effects of two different types of exercise on blood leukocyte numbers and blood leukocyte subsets. The changes in circulating cell counts, now to be discussed. Concurring with several other authors, [6, 11, 13, 14, 20] we observed a significant increase in total leukocyte, neutrophil and lymphocyte counts immediately following two types of exercise. Prolonged exercise (60% VO2max (90 min)) induced the greatest increase in total circulating leukocyte counts and neutrophil percent, but high intensity aerobic exercise (85% VO2max (30min)) induced a similar increase in lymphocyte percent. Numerous studies have established that intensive endurance exercise (70–85% VO_2max) induces a biphasic perturbation of the circulating leukocyte count [18]. Immediately post exercise, total leukocytes increase 50–100%, comprising all leukocyte types [18]. However, the magnitude of the leukocytosis is apparently related to the intensity and duration of exercise and seems to be most pronounced after strenuous endurance exercise [10]. In agreement with other investigators, the two types of exercise caused distinct yet significantly different increases in natural killer cell count immediately after exercise. Both Kendall et al.[6] and Nieman et al [14] observed an augmentation of the exercise-induced increase in natural killer cell count as the intensity of activity was increased. Presumably, catecholamine secretion and consequently cell demargination increase with the intensity of effort, and there may also be an intensity-related gradation of effects from increased intravascular shear stress. Gabriel et al [4] observed that the rise in natural killer cell count was correlated with the increase in heart rate; our data confirm this finding (results not shown), which is compatible with either a catecholamine or a shear-stress mediated response. However, the increased lymphocytosis also found in the present study has only been demonstrated by Nielsen et al. [12] with their 6-min maximal exercise protocol. Therefore, this finding may be more linked to the intensity rather than the duration of exercise.

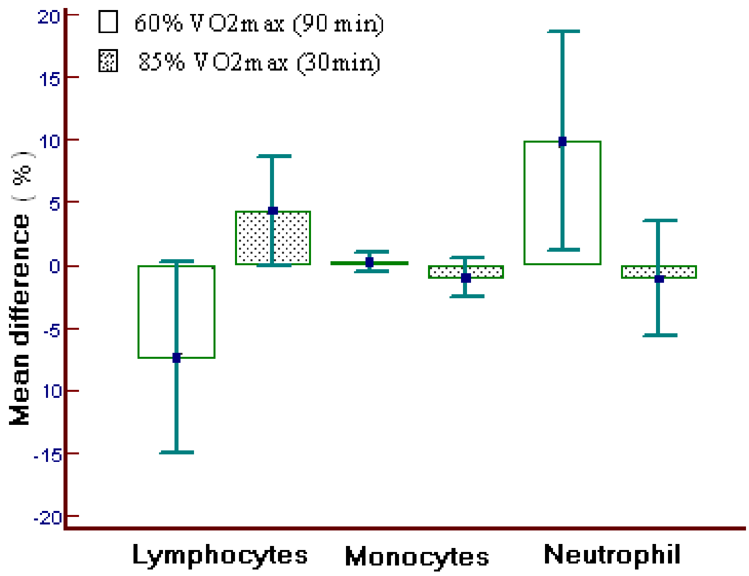

Figure2. Comparison of mean± SD differences of blood lymphocytes, monocytes and neutrophils subjects after two exercise program.

Several exercise experiments suggest that epinephrine and, to a lesser degree, norepinephrine mediate the early exercise effects on lymphocyte subpopulations, whereas cortisol is more involved in the post exercise concentration changes [1, 4, 5, 7, 9]. The immediate exercise effect on neutrophils is associated with changes in both catecholamines and growth hormone [17]. Thus one could speculate whether successive training sessions without complete recovery eventually may lead to a suppression of an athlete's immunocompetence and subsequently increased risk of infections. However, the link between exercise-induced immunosuppression and increased risk of infections has not yet been proven conclusively. To provide evidence for such a link, further investigations could apply an intensive repeated exercise protocol over a longer time period. In addition to the immune parameters studied here, examination of in vivo cellular responses to immunological challenges, such as skin tests, may be performed along with registration of infectious episodes verified by microbiological and/or serological tests.

CONCLUSION

This investigation has demonstrated that a high-intensity endurance exercise was associated with a more pronounced change in concentrations of lymphocytes, compared with a long term aerobic exercise performed at the same time of the day. Also, The results showed that when exercise is very prolonged, the diminution of innate immune function is greater, than or at least as great as that observed after fatiguing exercise at higher work rates. The sum of acute responses observed in this study may exert a protective effect against sickness and may be used to improve health and lifespan in athletes.

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