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Original article

Acute effects of high- and low-intensity exercise bouts on leukocyte counts

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Abstract

Background/Objective: It is widely accepted that physical exercise may bring about changes in the immune system. Even acute bouts of exercise can alter the number and function of leukocytes, but the degree of white blood cell trafficking depends on the intensity and duration of exercise. The aim of this study was to analyze the acute and short-term effects of exercise intensity on leukocyte counts and leukocyte subsets.
Methods: Nine physically healthy, active young males (21.0 ± 1.9 years) underwent three experimental trials: high exercise intensity [80% peak oxygen consumption (VO_{2peak})], low exercise intensity (40% VO_{2peak}), and the control condition (no exercise). Blood samples were collected prior to exercise, immediately after exercise, and 2 hours after exercise. Two-way analysis of variance for repeated measures was used to evaluate differences between the trials and the time-points, and to compare times within trials.
Results: There was a greater increase in the leukocyte count after high-intensity exercise, compared to the control condition ($p < 0.01$) and low-intensity exercise ($p < 0.01$). This effect was still present 2 hours after passive recovery ($p < 0.01$).
Conclusion: When the same participants were submitted to different exercise intensities, the acute and short-term effects of exercise on white blood cells were intensity-dependent immediately after exercise (i.e., lymphocytosis and monocytosis) and 2 hours after passive recovery (i.e., neutrophilia).

Keywords: Aerobic exercise; Immune system; Inflammatory response; White blood cell

Introduction

In clinical practice, total leukocyte counts and subsets are widely used to confirm inflammatory process-related acute immune system disturbances[1] that have been associated with the development of a number of conditions harmful to health.[2] However, a complex interplay between manifold genetic and environmental factors determine interpersonal variability in leukocytes.[3] A high interpersonal variation in white blood cell (WBC) counts has also been reported in physically active individuals.[4,5]

Despite the high interpersonal variation, it is widely accepted that physical exercise may promote changes in the immune system.[6,7] Even acute bouts of exercise can alter the number and function of leukocytes.[8] The degree of WBC trafficking depends on the intensity and duration of exercise.[9] It has been postulated

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that exercise increases stress-induced changes in the immune-neuroendocrine axis and in the circulating levels of metabolites that directly influence the function of immune cells.[10]

Natale et al[11] previously reported that aerobic training and resistance training induce changes in leukocyte counts in moderately fit individuals; by contrast, Nieman et al[12] did not find continuous or intermittent cycling on WBC in well-trained cyclists. Kendall et al[13] showed that the effects of exercise on leukocytes depend on the intensity, duration, and fitness level of individuals. These contradictory observations are intriguing. A variety of factors may have contributed to the conflicting data such as the fitness status of the individuals and differences in the exercise type, intensity, and duration. It is noteworthy that none of the previous studies evaluated the effects of different exercise intensities on leukocyte counts and subsets by standardizing the energy expenditure of the sessions and controlling the interpersonal variation in the WBC levels. The aim of this study was thus to analyze the acute and short-term effects of a single bout of aerobic exercise at low intensity and at high intensity on leukocyte counts and subsets in physically active young adults.

Methods

Participants

Nine healthy physically active young men (21.11 ± 1.90 years) of normal weight [body mass index (BMI), 19.9–25 kg/m^2] volunteered for this study. The exclusion criteria were chronic alcohol consumption, smoking and/or use of nutritional supplements, metabolic or endocrine diseases, and use of any anti-inflammatory drug. The study was conducted in accordance with the Helsinki Declaration and was approved by the University of Pernambuco's Ethics Committee (Recife, Brazil; approval number 154/08). All volunteers gave written, informed consent.

Experimental design

In this crossover study, the participants were assigned by simple randomization to three experimental sessions with a 7-day wash out: (1) the control session in which the participants remained seated for 2 hours (i.e., no exercise); (2) the low-intensity exercise (LIE) session in which the participants exercised on a treadmill at an intensity corresponding to 40% of peak oxygen consumption (VO_{2peak}); and (3) the high-intensity exercise (HIE) session in which the participants exercised on a treadmill at 80% VO_{2peak}. For the LIE and HIE sessions, the energy expenditure was set at 350 kcal, estimated by indirect calorimetry (e.g., direct gas analyses), based on the metabolic equivalent of task (MET). The energy expenditure is 4.96 kcal for each liter of O_2 consumed. All sessions were conducted under a steady-state condition and with a respiratory exchange ratio < 1.0 (control, 0.82 ± 0.05; LIE, 0.90 ± 0.04; HIE, 0.94 ± 0.05). Each participant served as his own control.

During the first visit to the laboratory, anthropometry and body composition were measured and VO_{2peak} was determined. On the remaining visits, the participants arrived at the laboratory around 7:00 AM, after fasting overnight. They were then weighed and were served a standard snack (350 kcal composed of 61.7% carbohydrates, 13.44% proteins, and 24.86% lipids). At 7:30 AM, the participants underwent a LIE session, a HIE session, or the control session, and subsequently remained seated for 2 hours. The trials were conducted in a temperature-controlled room (21–23°C) in randomized and were conducted at the same time of the day to avoid any circadian variations. Participants were asked to refrain from vigorous exercise for 48 hours prior to the sessions.

Anthropometry and body composition

The participants were weighed on a Filizola scale (Model 160/300; São Paulo, Brazil) to the nearest 0.1 kg while wearing light clothing and no shoes. Height was measured to the nearest 0.5 cm using a wall-mounted Filizola stadiometer (Model 160/300; São Paulo, Brazil). Body composition was determined by bioelectrical impedance (Biodynamics A-310 body composition analyzer; Biodynamics Corporation, Shoreline, New York, USA).[12]

VO_{2peak} determination

Oxygen consumption (VO_2) was directly measured using a continuous incremental treadmill test (Super ATL; Inbrasport, Porto Alegre, Brazil), as previously described. The inclination was set at 1.0%, and the initial workload was 5.0 km/h (4 minutes). The speed was thereafter increased to 1.0 km/h every minute. The termination criteria were volitional fatigue, a Borg scale value > 18, and gas exchange ratio > 1.15. The greatest VO_2 obtained prior to the test interruption was the VO_{2peak}. The VO_2 and carbon dioxide production (VCO_2) were analyzed breath by breath and displayed every 15 seconds in an open circuit respiratory metabolic system (Metalyzer IIB; Cortex Biophysik, Leipzig, Germany).

Blood leukocyte and subset counts

The complete routine tests for WBCs was performed using an automated method (Abbott Cell-Dyn 3700 Hematology Analyzer Features; Abbott Laboratories, St. Ana, USA). For the exercise trials, blood samples were obtained prior to the onset of exercise (i.e., baseline), immediately after exercise (i.e., acute), and 120 minutes after exercise (i.e., short-term). For the control trial, samples were collected at baseline, after 30 minutes (i.e., acute), and 120 minutes after baseline (i.e., short-term). The WBC count procedures were blindly performed.

Statistical analysis

All data were expressed by the mean and standard deviation. Analysis was performed using Statistica 8.0 software (Statistica 8, 2008; Statsoft Inc., Tulsa, OK, USA). Two-way analysis of variance (ANOVA) for repeated measures was used to evaluate differences between trials (i.e., control, LIE,