Effects of blood donation on exercise performance in competitive cyclists

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This study evaluated 10 male cyclists before and after phlebotomy to determine the effect of donation of 1 U of blood on exercise performance. Each subject underwent maximal exercise testing with oxygen consumption measurement at baseline, 2 hours after phlebotomy, 2 days after phlebotomy, and 7 days after phlebotomy. Maximal performance was decreased for at least 1 week. Submaximal performance was unaffected by blood donation. (Am Heart J 1995;130:838-40.)

Hundreds of thousands of people donate blood on a regular basis, but the effect of phlebotomy on exercise performance in the immediate postdonation phase has not been determined. This effect is of particular interest to athletes involved in competitive sports. Because of the concern about the effect of phlebotomy on performance, athletes may be hesitant to donate blood on a regular basis. The purpose of this investigation was to ascertain the effect of blood donation on the exercise performance of competitive athletes.

METHODS

The study group included 10 male amateur competitive cyclists who volunteered to donate blood and participate in the exercise protocol. Those enrolled in the study were acceptable candidates for blood donation as ascertained by the Lenox Hill Hospital Blood Donation Center. All volunteers had normal hematocrit levels as measured by the donor center. Exclusion criteria included (1) a history of cardiac, pulmonary, renal, or neuromuscular disease that precluded completion of a maximal cardiopulmonary exercise test; (2) history of hypertension, diabetes, or syncope and volunteers with recent symptoms of dizziness, weakness, or near-syncope; (3) donation of blood within the 2 months before enrollment into the study, blood donation five or more times within the past year, or evidence of recent blood loss.

Each subject performed a baseline maximal exercise study to determine maximal oxygen consumption and ventilatory threshold (VTh) approximately 1 week before blood donation. Subjects were instructed not to engage in any new exercise routine from their usual baseline activity, not to add new mineral supplements to their diet, and not to alter their daily dietary habits. Subjects performed an incremental test to exhaustion on a Monarch cycle ergometer under the supervision of a physician. The seat height was positioned by the subject and recorded so it would remain at that level for future testing. Work was increased 150 kilopond meters every minute.[1] Oxygen consumption was continuously measured with 20-second averaging by a Sensor Medics 2900 metabolic cart (Sensor Medics Corp., Yorba Linda, Calif.) that had been previously calibrated with standardized gases. The ECG was monitored continuously with three leads by a Sensor Medics Horizon 12-lead, and an ECG was performed periodically at approximately 2-minute intervals.

On the day of the baseline study an initial blood sample for measurement of venous lactate, hemoglobin, and hematocrit was drawn with the subject at rest. The subject was subsequently moved to the bicycle ergometer. During the baseline period, heart rate by ECG and blood pressure by auscultation of the brachial artery with a blood pressure cuff was monitored continuously and every two minutes, respectively. Resting oxygen consumption ($\dot{V}O_2$), carbon dioxide production ($\dot{V}CO_2$), and respiratory exchange ratio (R) was monitored with the mixing chamber method (Sensor Medics 2900). During exercise, VTh was determined by visual inspection of graphs of ventilatory equivalent for oxygen ($\dot{V}EO_2$) and carbon dioxide ($\dot{V}ECO_2$) by the methods of Wasserman.[2] The point at which $\dot{V}EO_2$ was lowest before showing an upward trend while $\dot{V}ECO_2$ was at a plateau was defined as VTh. Blood samples for assessment of venous lactate were drawn within 5 minutes into VO_{2peak}.

The previously described test method was repeated for each subsequent exercise test. Within 1 week of his baseline study, the subject donated a unit of whole blood at the Lenox Hill Hospital Blood Donation Center after signing the standard consent form available in the center. Half of the study group received, on an alternate selection basis, at the time of the phlebotomy (within 1 hour) an equiva-

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Table I. Changes in maximal exercise values

	Baseline	*2 Hr*	*2 Days*	*7 Days*
Vo_2 (ml/min)	4854 ± 209	4454 ± 228*	4464 ± 187*	4506 ± 217*
Heart rate beats/min	192 ± 4	189 ± 5	190 ± 5	189 ± 4
Watts	394 ± 13	369 ± 17†	360 ± 14†	366 ± 18†
LA (mmol/L)	8.4 ± 0.5	8.6 ± 0.6	8.9 ± 0.7	8.4 ± 0.8

*$p < 0.05$ from baseline.
†$p < 0.01$ from baseline.

Table II. Submaximal oxygen consumption

	Baseline	*2 Hr*	*2 Days*	*7 Days*
Heart rate				
130	1734 ± 277	2156 ± 285	2157 ± 285	1847 ± 266
150	2815 ± 274	2833 ± 282	2680 ± 299	2760 ± 247
170	3738 ± 293	3957 ± 308	3487 ± 310	3514 ± 260
VTh	3233 ± 142	3153 ± 143	3195 ± 120	3131 ± 146

lent intravenous volume of normal saline solution to the volume of blood that had been phlebotomized. The entire study group was directed to follow the instructions of the Blood Donation Center to increase oral intake of fluids. General guidelines recommend that donors should drink at least one glass of fluids immediately after phlebotomy and thereafter be allowed to drink liberally. Two hours after phlebotomy each subject completed a symptom-limited maximal exercise test similar to the one he underwent on his baseline day of testing. Blood samples were similarly drawn. Repeat exercise tests and data acquisition were performed 2 days and 7 days after blood donation.

RESULTS

Baseline exercise test values showed a mean peak work level of 394 W and peak oxygen consumption of 4854 ml/min. There was no significant difference in exercise performance between the group that received intravenous saline after phlebotomy and the group that received only oral fluids. Thus the results for these two subgroups were combined for further analysis. There was no difference in hemoglobin level between baseline and 2 hours after phlebotomy (14.8 vs 14.5 mg/dl). Hemoglobin was significantly lower 2 days and 7 days after phlebotomy (14.8 vs 13.9 and 13.8, $p = 0.01$).

There was a significant fall in maximal exercise performance (reflected by watts achieved and Vo_2peak) during the 2-hour, 2-day, and 7-day post-phlebotomy studies compared to baseline (Table I). The consistency in the athletes' peak heart rates and maximal lactates suggests similar maximal efforts despite the reduction in Vo_{2peak}. There was no significant difference in oxygen consumption at submaximal exercise levels (heart rates of 130, 150, and 170 beats/min and at VTh) when comparing baseline exercise test to testing at 2 hours, 2 days, and 7 days after phlebotomy (Table II).

DISCUSSION

The results indicate that maximal exercise performance is significantly decreased for at least 7 days after phlebotomy in well-trained competitive cyclists. Submaximal exercise is unaffected by blood donation over the 7-day period after phlebotomy.

Other investigators have studied the effect of phlebotomy on exercise performance.[3, 4] For example, Ekblom et al.[3] found that phlebotomizing normal adults 800 or three 400 ml volumes at 4-day intervals resulted in a decreased Vo_{2max} of 13% and 18%, respectively.[3] When these subjects were reinfused with blood, there was an increase of 9% in their Vo_{2max} 1 day after reinfusion. The present study is unique in that it was designed to evaluate the effect of the degree of phlebotomy commonly associated with blood donation.

The average volume of blood that is usually phlebotomized in a normal healthy adult during a blood bank donation is approximately 450 ml, which is ⟨10% of a normal adult's total blood volume. A 10% to 20% acute loss of blood volume is usually characterized by minimal or no clinical manifestations but may be associated with vasovagal syncope, tachycardia in response to exercise, or mild postural hypotension.

Acute blood loss in the healthy adult is usually characterized by a sequence of two physiologic and hematologic phases.[5] The first phase reflects the acute hypovolemic event, during which there is usually no change in hematocrit levels (as observed in our study 2 hours after phlebotomy) because the hematocrit is reduced proportionately to a reduction in plasma volume. The second phase, after the acute blood loss, is hallmarked by the beginnings of reticulocytosis and the drop in hemoglobin and hematocrit levels (also observed in our study at 2 and 7 days after phlebotomy) reflecting the dilutional aspects of replenishing the intravascular volume.

Although hematocrit levels 2 hours after phlebotomy were similar to those baseline, the total oxygen-carrying capacity had fallen. This is probably the mechanism for the fall in Vo_{2max} 2 hours after phlebotomy. This pattern also holds true at 2 days and at 7 days after phlebotomy, when total-body oxygen-carrying capacity is diminished as reflected in the drop in hemoglobin and hematocrit levels. That there was no change in submaximal values probably indicates that at this level of stress the subjects' oxygen-carrying capacity was not limited (compared to baseline) by the degree of phlebotomy performed.

The infusion of normal saline solution into 5 of the 10 subjects had no significant statistical effect on exercise performance between the two groups, indicating that volume loss is not a factor in reduction of exercise performance or that the volume of saline infused was inadequate to make a difference. The volume of saline infused was equal to the volume phlebotomized, but only one third of the infused saline would be expected to remain the intravascular space. It is possible that more effective expansion of blood volume with infusion of 1200 ml of normal saline solution (i.e., three times the blood volume phlebotomized) would show a significant effect.[6]

Although the current study demonstrated that maximal exercise is affected by the donation of blood, athletes should not be discouraged from donating blood during their noncompetitive season. Maximal oxygen-carrying capacity is not stressed at submaximal work rates, a fact that coincides with our findings that submaximal values were not affected by blood donation. During training, most of an athlete's activity occurs at submaximal metabolic rates, and blood donation would probably not have a significant effect on performance. Competition involving maximal metabolic rates is, however, likely to be affected for at least 1 week after blood donation.

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