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# Blood doping: Is it really worth it

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**Abstract**
Blood doping is an illicit method of improving athletic performance by artificially boosting the blood's ability to bring more oxygen to muscles. In many cases, blood doping increases the amount of haemoglobin in the bloodstream. Haemoglobin is an oxygen-carrying protein in the blood. So increasing haemoglobin allows higher amounts of oxygen to reach and fuel an athlete's muscles. This can improve stamina and performance, particularly in long-distance events, such as running and cycling. Blood doping is banned by the International Olympic Committee and other sports organizations. In normal medical practice, patients may undergo blood transfusions to replace blood lost due to injury or surgery. Transfusions also are given to patients who suffer from low red blood cell counts caused by anemia, kidney failure, and other conditions or treatments.

**Keywords:** blood doping, r.b.c, blood transfusions.

## 1. Introduction
Once any starting gun is fired at an Olympic event, every split second counts to the elite athletes. And that's where blood doping comes in, particularly in endurance sports.
Blood doping refers to a handful of techniques used to increase an individual's oxygen-carrying red blood cells, and in turn, improve athletic performance. The most commonly used types of blood doping include injections of erythropoietin (EPO), injections with synthetic chemicals that can carry oxygen, and blood transfusions, all of which are prohibited under the World Anti-Doping Agency's (WADA) List of Prohibited Substances and Methods. EPO is produced naturally by the body. The hormone gets released by the kidneys and causes the body's bone marrow to pump out red blood cells. Red blood cells shuttle oxygen through a person's blood, so any boost in their numbers can improve the amount of oxygen the blood can carry to the body's muscles. Then end result is more endurance. "Blood doping reduces fatigue by increasing the supply of oxygen to the exercising muscles," said Michael Joyner, an anesthesiologist at the Mayo Clinic in Minnesota. "This will not increase the maximum force the muscle can generate but will permit the muscle to do more work for longer." When used for legitimate medical reasons, EPO helps with the treatment of anemia related to cancer or kidney disease. Blood transfusions involve drawing out your own blood and storing it for a few months while your body replenishes its red blood-cell supplies. Then, before the competition, the athlete would re-inject the blood back into his or her body. The outcome is similar to that of EPO — a bump in red blood cells. WADA suggests there has been a resurgence of blood transfusions with the introduction of an EPO-detection method in 2000. For athletes, the extra bump can mean the difference between a gold and silver medal, or whether or not you break a world record. "Blood doping" refers to any illicit method of boosting an athlete's red blood-cell supply in advance of competition. The typical adult male's hematocrit. The percentage of his blood that is composed of red blood cells hovers around 45. Since red blood cells carry oxygen through the bloodstream, increasing the number of them allows an athlete's blood to deliver oxygen to muscles more efficiently, reducing fatigue and giving the athlete an edge. Endurance athletes often train at high altitude for precisely this reason. The lower air pressure and diminished atmospheric oxygen at altitude spur the body to generate extra red blood cells, and can bump the hematocrit up two or three (non-illicit) percentage points. Athletes can get a bigger and illegal boost by injecting themselves with erythropoietin (EPO), a hormone that stimulates RBC production.
A urine test for artificial EPO was introduced in 1997, but it's not foolproof; while testable traces of artificial EPO disappear from an athlete's body within four days, the hormone's effects are strongest three weeks after injection.

Hamilton is suspected of using a different method of blood doping, one that requires no hormones; instead, concentrated red blood cells are transfused directly into the bloodstream a week or less before competition. For reasons of convenience and safety, autologous transfusions, in which the cells are the athlete's own, are reportedly far more common than homologous transfusions, in which the cells belong to someone else with compatible blood. Typically, an athlete has up to four units of blood removed a month or more before competition. Technicians then use a centrifuge to separate the red blood cells from this sample; the RBCs are placed in cold storage, only to be reinfused shortly before the big race. (The athlete may even use EPO months before an event to boost the number of RBCs in the units of blood that get removed; the EPO will be undetectable by race day.)In the past, the only way to test for blood doping was by testing an athlete's blood for an unnaturally high hematocrit; the International Cyclist Union (UCI) bans racers for 15 days if random tests turn up a hematocrit over 50. Hamilton is the first athlete to receive a positive result from a new homologous transfusion test, developed in Australia by Dr. Michael Ashenden's team at Science and Industry Against Blood Doping and introduced at this year's Tour de France. Based on methods used in hospitals to differentiate between maternal and fetal blood in pregnant women, the new test distinguishes among nearly 200 different proteins present in blood cell walls, and can identify blood types far more specific than the A, B, and O on your donor card. Blood doping is the act of adding red blood cells to an individual's bloodstream. Why red blood cells? Red blood cells carry oxygen, and an increase of oxygen in the bloodstream raises the supply of oxygen available to muscle. By increasing the volume of oxygen available to one's muscles, muscles perform more efficiently. With this increased efficiency comes an increase in athletic endurance, allowing blood doping to benefit cyclists, swimmers, and long distance runners. Athletes regularly underwent doping procedures prior to events before the banning of blood doping in Olympic competition in 1985. The red blood cells come from two very different methods one is gory and old school, while the other involves hormone injections. The oldest form of blood doping involves obtaining fresh blood and extracting the oxygen carrying red blood cells. The extracted red blood cells are then frozen and stored. Prior to competition, the athlete undergoes a clandestine intravenous infusion to add the red blood cells to their circulatory system. The blood can come from the athlete desiring to dope, but if it does, he or she will likely become anemic for a short period after donation. The concentrated red blood cells can also come from compatible third party donors. This method allows for a larger storied supply, more opportunities to dope, and negates the possibility of anemia in the athlete. Using an outside donor, however, introduces the risk of obtaining a communicable disease or undergoing a transfusion rejection. Red blood cell transfusions are detected in tests looking for the presence of organic molecules known as plasticizers in blood samples. These molecules are commonly sloughed from IV bags, bags used to store and transfer concentrated red blood cells. Biochemical markers detecting the presence of red blood cells from multiple individuals in an athlete also tip off officials to blood doping. Erythropoietin (EPO) is used by athletes to increase red blood cell counts in a less gruesome manner. Erythropoietin is a protein that stimulates the production of red blood cells. The use of erythropoietin eliminates the problems that come along with obtaining and storing red blood cells, as well as clandestine operations to infuse one's blood with the red blood cells prior to an event. Erythropoietin is normally produced by the kidneys, with the hormone binding to receptors in the blood marrow and increasing red blood cell production. The protein can be created and purified through recombinant methods, with erythropoietin created in this manner available for purchase as a pharmaceutical for treatment of anemia. The use of erythropoietin, however, is outlawed in most sports. Catching blood dopers who use erythropoietin is tricky, as increased levels EPO can only be detected in the first few days after injection. Urine tests looks for differences between pharmaceutical EPO and the athlete's own EPO, as the mass of the two proteins slightly differ.Checking total red blood cell counts within an athlete's blood is another common test. The red blood cell levels for males and females are well established. Spikes in red blood cell count are often an indirect signal that an athlete is doping. Increasing the amount of red blood cells in one's circulatory system is not without risks. Blood doping brings with it an increase in blood viscosity, making blood clots much more likely and increasing the risk of stroke. The communicable diseases and risk of blood contamination inherent in transfusion of red blood cells will always be problem, but one that can be eliminated with proper screening of donors.

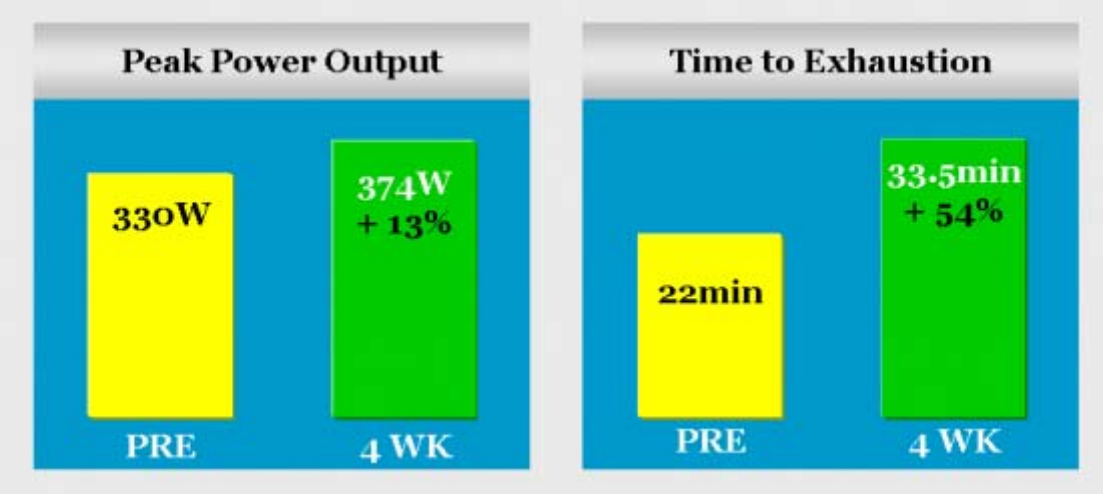
**Effects on Performance**

Blood doping is most commonly used by endurance athletes, such as distance runners, skiers and cyclists. By increasing the number of red blood cells within the blood (and so increasing the haematocrit), higher volumes of the protein haemoglobin are present. Haemoglobin binds to and carries Oxygen from the lungs, to the muscles where it can be used for aerobic respiration. Blood doping therefore allows extra Oxygen to be transported to the working muscles, resulting in a higher level of performance, without the use of the anaerobic energy systems. In previous posts, we've looked at the data from the East German doping "machine" published by Franke & Berendonk in 1997 in Clinical Chemistry, looked at the effect of a steroid programme on performance. That paper showed a great example of how a 'mediocre' shot-put athlete became a world record holder, driven on by a 17% improvement in ONE season. But, that was steroids, not the most widely used drugs in cycling, though they are certainly used, if the tests and testimonies are believed. There are benefits to using steroids, for sure, in that they will assist in recovery. There is ample evidence of how testosterone levels fall progressively during a period of hard training or racing and so the correct use of steroids will improve recovery and thus performance in the longer races. But we're more interested in EPO. There is plenty of evidence that shows indirect benefits, including Marco Pantani's remarkble hematocrit graph, which correlated precisely with his performance over the course of three seasons. But it's direct evidence we're after, and that's where we turn to a study published in August this year. EPO improves performance by 54% in a laboratory trial This great study, published in the European Journal of Applied Physiology earlier this year, evaluated the effects of EPO use on performance during cycling. We'll try to break the

study down as simply and clearly as possible: Who was tested? They had 16 reasonably fit cyclists take part in the study. The pre-testing VO2max tests showed an average VO2 of about 3.90L/min and a Peak Power Output of 325 W. By no means world-class cyclists, but fit athletes. This does have some implications for the application of the data, which we'll get to later. How were they tested? The testing involved an 13-week period, where the 16 athletes were split into two groups. The control group received placebo injection, whereas the 8 cyclists in the EPO group received a dosage of EPO on a schedule worked out over the 13-week period. One potential problem with the study was that the EPO group could not be blinded that they were receiving EPO, for ethical reasons. What this means is that everyone receiving EPO KNEW that they were, and there's good reason to believe that simply knowing you're receiving a drug improves performance as well! The control subjects were blinded, so they did not know whether they were on EPO or not, which does partly offset this problem. Measures of performance? All the athletes were tested BEFORE and AFTER the injections doing two performance-trials:

- Peak Power Output testing – here, the subjects start off riding at a low power output and the workload increases every 90seconds until exhaustion. Basically, the cyclist has to go harder and harder until they cannot push anymore! The test is used to measure VO2max and also a Peak Power Output
- This was followed by a Trial to Exhaustion at 80% of the previously determined Peak Power Output. In this trial, the cyclist rides at ONE power output – 80% of their maximum, and they ride until exhaustion. This test is used as a measure of endurance performance. This trial was done after 4 weeks and again after 11 weeks of the trial.

The results: A 54% improvement in performance We don't wish to go into all the blood analysis and DEXA work done – they measured all kinds of things, but this is a post about performance. And the main finding was that EPO use improved time to exhaustion by an enormous 54% within 4 weeks! Peak Power Output improved by 13% in the first four weeks of the trial. The graph below shows the results:




**Side Effects**

The main side effects of blood doping include:

- the formation of blood clots,
- overload of the circulatory system,
- kidney damage from *allergic* reactions and
- transmission of infectious diseases like HIV.

Further side effects may be:

- rash, fever and shock due to an *allergic* reaction,
- metabolic shock,
- acute hemolytic reactions with kidney damage if incorrectly typed blood is used,
- delayed transfusion reactions resulting in fever and *jaundice* (potentially life-threatening) and
- transmission of infectious diseases (viral *hepatitis* and AIDS). Even in standard hospital conditions, the risk of infections with such pathogens as HIV and *hepatitis*, as well as transfusion reactions require a detailed carefully performed procedure. The unsupervised practice of transfusing blood products could increase those risks. In addition, raising one's hematocrit beyond physiologically normal levels leads to an increase in blood viscosity, thrombogenic potential and myocardial infarction risk.

**Artificial oxygen carriers**

The side effects of artificial oxygen carriers vary significantly and they include:

- fever,
- reduced platelet counts,
- hypertension,
- vasoconstriction,
- gastrointestinal irritability,
- impaired oxygen delivery to *tissues*,
- kidney damage and
- iron overload.

Particularly, high peripheral and pulmonary pressures under artificial oxygen carriers' administration may be present. When oxygen concentration in the tissue is high, a hyperoxic arteriolar reflex might reduce the number and diameter of functional capillaries to avoid oxidative tissue damage, thus increasing vascular resistance. Furthermore, hemoglobin based oxygen carriers reduce the nitric oxide-mediated vasodilatation in arterioles and capillaries. Other adverse effects are gastrointestinal manifestations with increased tone of the intestinal sphincters, marked flatulent

activity and meteorism. Renal toxicity, induced by filtration of hemoglobin monomers and consecutive tubulus necrosis, represents a potentially fatal adverse reaction of these substances. Blood products derived from hemoglobin of human or bovine origin might contain infective agents such as viruses or induce immuneogenic effects in the recipient. Adverse effects associated with the use of perfluorocarbons include flu-like symptoms with fever and myalgias. Perfluorocarbons have also been linked to hepatic or spleenal engorgement with consecutive organ failure and impairment of immune defense mechanisms.

Further side effects can be:

- *allergic* reactions may occur,
- increase in body temperature above 40 °C,
- fever and cold,
- diarrhea,
- kidney, liver and lung toxicity (the lesions are probably irreversible in most cases),
- blood infections if the preparations are bacteriological impure,
- severe conditions such as embolism and thromboses (thrombocytopenia),
- risk of AIDS virus transmission if needles are shared,
- formation of gas bubbles once injected into the blood vessels.

**Conclusion**

At the nearby time blood doping is a contentious matter. With the new proceeds in science and sports medicine, this will possibly be a predicament for years to come. Many present and future athletes will have to use their greatest decision when this process becomes an matter in their lives. Blood doping is prohibited but is also untraceable. The prospective risks of such a process seem to overshadow any probable payback, above and further than the decent issues involved. If a separate benefit is needed in stamina events, altitude training and the altitude sleep cavity pose far fewer risks and are presently safe and lawful. And, if all else fails, hard work and strength of mind still calculate for something.

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