International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw,
Poland 00-773
+48 226 0 227 03
editorial_office@rsglobal.pl

ARTICLE TITLE	THE IMPACT OF WHOLE BLOOD DONATION ON ATHLETIC PERFORMANCE
DOI	https://doi.org/10.31435/ijitss.4(48).2025.4357
RECEIVED	27 October 2025
ACCEPTED	20 December 2025
PUBLISHED	26 December 2025
LICENSE	The article is licensed under a **Creative Commons Attribution 4.0 International License.**

THE IMPACT OF WHOLE BLOOD DONATION ON ATHLETIC PERFORMANCE

Magdalena Zięba *(Corresponding Author, Email: magdalenaxzieba@gmail.com)*
Gabriel Narutowicz Municipal Specialist Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0009-3281-1725

Szymon Rudawski
The University Hospital in Krakow, Kraków, Poland
ORCID ID: 0009-0000-4793-3244

Maja Elertowicz
Ludwik Rydygier Memorial Hospital in Kraków, Kraków, Poland
ORCID ID: 0009-0002-8802-0323

Kateryna Shtohryn
Jagiellonian University Medical College, Kraków, Poland
ORCID ID: 0009-0009-9134-4741

Hubert Gugulski
The University Hospital in Krakow, Kraków, Poland
ORCID ID: 0009-0004-1294-9835

Magdalena Morytko
The University Hospital in Krakow, Kraków, Poland
ORCID ID: 0009-0005-3913-4457

Mikołaj Moskwa
Jagiellonian University Medical College, Kraków, Poland
ORCID ID: 0009-0006-4404-8243

Patrycja Herod
Ludwik Rydygier Memorial Hospital in Kraków, Kraków, Poland
ORCID ID: 0000-0002-4232-771X

Aleksandra Wójciak
The New Hospital in Olkusz, Olkusz, Poland
ORCID ID: 0009-0003-2398-863X

ABSTRACT

Introduction and Purpose: Whole blood donation induces acute hematological alterations that may temporarily impair aerobic performance, particularly in athletes whose training and competition outcomes depend on maximal oxygen transport capacity. This review aims to synthesize current evidence regarding the physiological and performance-related consequences of a standard whole blood donation (450-500 mL), with particular emphasis on changes in hemoglobin concentration, hemoglobin mass, maximal oxygen uptake (VO_2max), and recovery timelines.

Results: Across controlled studies published between 1990 and 2025, whole blood donation consistently reduces hemoglobin concentration by approximately 7-10% within 24-48 hours, accompanied by a 5-10% decline in VO_2max. These hematological and physiological changes result in measurable reductions in maximal exercise capacity, including decreased peak power output and shorter time to exhaustion. Submaximal exercise responses are largely preserved, suggesting that functional impairment is most pronounced at intensities near or at VO_2max. Full restoration of hemoglobin mass and maximal aerobic performance typically requires 3-6 weeks and is strongly influenced by individual iron status, donation frequency, and training load. Plasma donation, by contrast, does not appreciably affect VO_2max but may transiently alter anaerobic performance due to reduced buffering capacity.

Conclusion: Whole blood donation transiently diminishes oxygen-carrying capacity and maximal aerobic performance by reducing hemoglobin concentration and total hemoglobin mass. While these effects are reversible, recovery can be prolonged in individuals with low iron stores or high endurance demands. Understanding the magnitude and time course of these changes is essential for athletes, coaches, and clinicians in planning training and competition schedules. Recognition of the physiological mechanisms involved may also guide the development of individualized donation strategies and iron management protocols for athletic populations.

KEYWORDS

Blood Donation, VO_2max, Athletic Performance, Iron Deficiency, Hemoglobin

CITATION

Magdalena Zięba, Szymon Rudawski, Maja Elertowicz, Kateryna Shtohryn, Hubert Gugulski, Magdalena Morytko, Mikołaj Moskwa, Patrycja Herod, Aleksandra Wójciak. (2025). The Impact of Whole Blood Donation on Athletic Performance. *International Journal of Innovative Technologies in Social Science*. 4(48). doi: 10.31435/ijitss.4(48).2025.4357

Introduction

Whole blood donation is widely practiced and remains essential in contemporary healthcare systems (Myers & Collins, 2024). Although physiologically safe, it induces acute reductions in red blood cell (RBC) mass, hemoglobin concentration, hematocrit, and arterial oxygen-carrying capacity (Gasparovic Babic et al., 2024). Because aerobic performance relies heavily on oxygen delivery to working tissues, these changes may temporarily impair maximal exercise capacity.

A typical whole blood donation removes approximately 8–10% of total RBC mass, resulting in measurable declines in VO_2max and maximal work capacity (Van Remoortel et al., 2017). Controlled studies demonstrate that VO_2max decreases by roughly 5–10% during the first 48 hours post-donation (Hill et al., 2013). Submaximal performance is generally preserved, suggesting that reductions in oxygen availability primarily affect maximal or near-maximal efforts.

With increasing numbers of athletes participating in donor programs, understanding the physiological consequences, recovery timelines, and potential mitigation strategies is important (Kanagasabai, 2021). This review summarizes current evidence and provides practical guidance for sport and health professionals.

Methods

A structured literature search was conducted using PubMed, Scopus, Google Scholar, and ProQuest. Search terms included “blood donation,” “VO_2max,” “hemoglobin mass,” “aerobic performance,” and “athletes.” Peer-reviewed studies examining physiological or performance-related outcomes after whole blood or plasma donation were included. Systematic reviews, randomized controlled trials, crossover designs, and laboratory-based experimental studies were prioritized.

Results

Evidence consistently demonstrates that hemoglobin concentration and hematocrit decrease by 7-10% within the first 24-48 hours following whole blood donation (Van Remoortel et al., 2017). Total hemoglobin mass requires a longer period to recover-typically 3-6 weeks-and recovery is influenced by iron status and training level (Meurrens et al., 2016).

Maximal aerobic performance shows a parallel decline: VO_2max decreases by approximately 5-10% post-donation (Hill et al., 2013), accompanied by reductions in peak power output and time to exhaustion. Recovery of VO_2max aligns closely with the restoration of hemoglobin mass (Schmidt & Prommer, 2010).

Submaximal exercise responses-such as steady-state VO_2, lactate threshold, and heart rate-exhibit little to no impairment. Plasma donation, which does not reduce RBC mass, has minimal influence on VO_2max but may transiently affect anaerobic performance through reductions in buffering capacity (Hill et al., 2013).

Iron status plays an important role in recovery. Individuals with low ferritin levels or those who donate frequently experience slower restoration of hemoglobin concentration and aerobic performance (Meurrens et al., 2016).

Discussion

Whole blood donation produces predictable short-term reductions in hematological variables and maximal aerobic capacity. Because VO_2max is strongly limited by oxygen delivery at maximal intensities, even modest decreases in hemoglobin mass can meaningfully reduce maximal aerobic performance. These effects are most evident during the first 24-48 hours after donation (Van Remoortel et al., 2017).

Submaximal performance remains largely unaffected, allowing athletes to maintain low-intensity training shortly after donation. However, endurance athletes-whose performance depends heavily on maximal oxygen transport-may experience more pronounced decrements. Plasma donation may offer a practical alternative for athletes, given its minimal impact on aerobic performance (Saltzmann, 2023).

Iron status is a critical determinant of recovery speed. Frequent donors or individuals with low baseline ferritin may require extended recovery timelines or targeted iron supplementation (Meurrens et al., 2016; Vassallo et al., 2020).

The available evidence is limited by small sample sizes, heterogeneous methodologies, and inconsistent timing of post-donation measurements. Many studies include recreational rather than elite athletes, reducing generalizability to high-performance populations. Additionally, long-term adaptation to repeated donations remains understudied, and many investigations rely on concentration-based hematological measures rather than direct assessment of hemoglobin mass.

Future research should investigate sex-specific responses, the cumulative effects of repeated donations on long-term training adaptation, and individualized recovery timelines. Studies employing standardized exercise protocols and direct measurements of hemoglobin mass (e.g., CO rebreathing) would improve comparability. Predictive modeling approaches, such as machine-learning models for iron recovery, may also support personalized donation strategies for athletes.

Athletes should avoid whole blood donation during the 2–3 weeks preceding major competitions. Low-intensity training can generally continue during the early post-donation period, while high-intensity or maximal aerobic sessions should be temporarily reduced. Regular donors should monitor ferritin levels and consider iron supplementation under medical supervision. Plasma donation remains a viable alternative for athletes who wish to donate without compromising performance.

Conclusions

Whole blood donation temporarily reduces hemoglobin concentration, hemoglobin mass, VO_2max, and maximal exercise capacity due to the immediate loss of red blood cells and the resulting decrease in oxygen-carrying capacity. Although submaximal performance is largely preserved, activities requiring sustained maximal or near-maximal aerobic output are consistently impaired during the initial post-donation period. Full recovery of hemoglobin mass and aerobic performance may require several weeks, particularly in individuals with low baseline iron stores, high endurance training loads, or increased erythropoietic demands. These findings underscore the importance of strategic planning around donation timing, especially for competitive athletes who must coordinate their training cycles and race schedules with physiological recovery. Incorporating routine monitoring of ferritin levels, ensuring adequate dietary iron intake, and considering iron supplementation where appropriate may support more efficient restoration of hematological parameters. Moreover, the observed differences between whole blood and plasma donation highlight a practical alternative for athletes wishing to participate in donor programs without compromising aerobic performance. Plasma donation, which preserves red blood cell mass, results in negligible reductions in VO_2max and may therefore be a more suitable option during intensive training phases. Ultimately, recognizing the physiological consequences of blood donation can help athletes, coaches, and clinicians make informed decisions that balance public health needs with athletic performance goals. Continued research into individualized recovery trajectories, iron metabolism, and donor management strategies will further refine evidence-based guidelines for athletic populations.

Funding Statement: The article did not receive any funding.
Conflict of Interest Statement: No conflicts of interest to declare.

REFERENCES

1. Van Remoortel, H., De Buck, E., Compernolle, V., Deldicque, L., & Vandekerckhove, P. (2017). The effect of a standard whole blood donation on oxygen uptake and exercise capacity: A systematic review and meta-analysis. Transfusion, 57(2), 451–462. https://doi.org/10.1111/trf.13893
2. Meurrens, J., Steiner, T., Ponette, J., Janssen, H., Ramaekers, M., Wehrlin, J., & Deldicque, L. (2016). Effect of repeated whole blood donations on aerobic capacity and hemoglobin mass. Sports Medicine - Open, 2(1), 43. https://doi.org/10.1186/s40798-016-0067-7
3. Schmidt, W., & Prommer, N. (2010). Impact of alterations in total hemoglobin mass on VO_2max. Exercise and Sport Sciences Reviews, 38(2), 68–75. https://doi.org/10.1097/JES.0b013e3181d4957a
4. Hill, D. W., Vingren, J. L., & Burdette, S. D. (2013). Effect of plasma and blood donation on aerobic and anaerobic responses. Applied Physiology, Nutrition, and Metabolism, 38(5), 551–557. https://doi.org/10.1139/apnm-2012-0361
5. Gordon, D., Marshall, K., Connell, A., & Barnes, R. (2010). Influence of blood donation on oxygen uptake kinetics during moderate and heavy intensity cycle exercise. International Journal of Sports Medicine, 31(5), 298–303. https://doi.org/10.1055/s-0030-1248321
6. Gordon, D., Wood, M., Porter, A., et al. (2014). Influence of blood donation on the incidence of plateau at VO_2max. European Journal of Applied Physiology, 114(1), 21–27. https://doi.org/10.1007/s00421-013-2743-3
7. Strandenes, G., Skogrand, H., Spinella, P., et al. (2013). Donor performance of combat readiness skills of special forces soldiers are maintained immediately after whole blood donation: a study to support the development of a prehospital fresh whole blood transfusion program. Transfusion, 53(3), 526–530. https://doi.org/10.1111/j.1537-2995.2012.03767.x
8. Gasparovic Babic, S., Krsek, A., & Baticic, L. (2024). Voluntary Blood Donation in Modern Healthcare: Trends, Challenges and Opportunities. *Epidemiologia (Basel, Switzerland)*, *5*(4), 770–784. https://doi.org/10.3390/epidemiologia5040052
9. Myers, D. J., & Collins, R. A. (2024). Blood Donation. In *StatPearls*. StatPearls Publishing. PMID: 30247842
10. Kanagasabai, U., Selenic, D., Chevalier, M. S., Drammeh, B., Qualls, M., Shiraishi, R. W., Bock, N., Benech, I., & Mili, F. D. (2021). Evaluation of the WHO global database on blood safety. *Vox sanguinis*, *116*(2), 197–206. https://doi.org/10.1111/vox.13001
11. Bednall, T. C., & Bove, L. L. (2011). Donating blood: a meta-analytic review of self-reported motivators and deterrents. *Transfusion medicine reviews*, *25*(4), 317–334. https://doi.org/10.1016/j.tmrv.2011.04.005
12. Janetzko, K., Böcher, R., Klotz, K. F., Kirchner, H., & Klüter, H. (1998). Effects of blood donation on the physical fitness and hemorheology of healthy elderly donors. *Vox sanguinis*, *75*(1), 7–11. PMID: 9745147
13. Houser, A. P., Soto, M. A., Bell, K. S., Goldberg, P. G., Cronin, K. J., Caldwell, R. C., & Schilling, B. K. (2025). Effect of Fresh Whole Blood Donation on Human Performance in United States Special Forces. *Journal of special operations medicine : a peerreviewed journal for SOF medical professionals*, *25*(1), 23–28. https://doi.org/10.55460/7TZF-0HBX
14. Jones, D. M., Roberts, N., Weller, R. S., McClintock, R. J., Buchanan, C., & Dunn, T. L. (2025). Effects of Whole Blood Donation on Physiological Responses and Physical Performance at Altitude. *Journal of special operations medicine : a peer reviewedjournal for SOF medical professionals*, *25*(1), 29–34. https://doi.org/10.55460/ZXN7-EFUJ
15. Myers, D. J., & Collins, R. A. (2024). Blood Donation. In *StatPearls*. StatPearls Publishing. PMID: 30247842
16. Williams, M. H., Lindhjem, M., & Schuster, R. (1978). The effect of blood infusion upon endurance capacity and ratings of perceived exertion. *Medicine and science in sports*, *10*(2), 113–118. PMID: 692300
17. Fritsch, J., Winter, U. J., Reupke, I., Gitt, A. K., Berge, P. G., & Hilger, H. H. (1993). Einfluss einer einmaligen Blutspende auf die ergospirometrisch bestimmte kardiopulmonale Leistungsfähigkeit bei jungen gesunden Probanden [Effect of a single blooddonation on ergo-spirometrically determined cardiopulmonary performance capacity of young healthy probands]. *Zeitschrift fur Kardiologie*, *82*(7), 425–431. PMID: 8379242

18. Markiewicz, K., Cholewa, M., Górski, L., Jaszczuk, J., Chmura, J., & Bartniczak, Z. (1981). Effect of 400 ml blood loss on adaptation of certain functions of the organism to exercise. *Acta physiologica Polonica*, *32*(6), 613–621. PMID: 6816010
19. Pengelly, M., Pumpa, K., Pyne, D. B., & Etxebarria, N. (2024). Iron deficiency, supplementation, and sports performance in female athletes: A systematic review. *Journal of sport and health science*, *14*, 101009. Advance online publication. https://doi.org/10.1016/j.jshs.2024.101009
20. Birnbaum, L., Dahl, T., & Boone, T. (2006). Effect of blood donation on maximal oxygen consumption. *The Journal of sports medicine and physical fitness*, *46*(4), 535–539. PMID: 17119517
21. Bennett-Guerrero, E., Rizwan, S., Rozensky, R., Romeiser, J. L., Brittelli, J., Makaryus, R., Lin, J., Galanakis, D. K., Triulzi, D. J., & Moon, R. E. (2021). Randomized controlled trial of 7, 28, vs 42 day stored red blood cell transfusion on oxygen delivery(VO2 max) and exercise duration. *Transfusion*, *61*(3), 699–707. https://doi.org/10.1111/trf.16237
22. Duda, K., Zoladz, J. A., Majerczak, J., Kolodziejski, L., & Konturek, S. J. (2003). The effect of exercise performed before and 24 hours after blood withdrawal on serum erythropoietin and growth hormone concentrations in humans. *International journal of sports medicine*, *24*(5), 326–331. https://doi.org/10.1055/s-2003-40709
23. Skattebo, Ø., Johansen, E. S., Capelli, C., & Hallén, J. (2021). Effects of 150- and 450-mL Acute Blood Losses on Maximal Oxygen Uptake and Exercise Capacity. *Medicine and science in sports and exercise*, *53*(8), 1729–1738. https://doi.org/10.1249/MSS.0000000000002618
24. Kiss, J. E., & Vassallo, R. R. (2018). How do we manage iron deficiency after blood donation?. *British journal of haematology*, *181*(5), 590–603. https://doi.org/10.1111/bjh.15136
25. Kiss, J. E., Brambilla, D., Glynn, S. A., Mast, A. E., Spencer, B. R., Stone, M., Kleinman, S. H., Cable, R. G., & National Heart, Lung, and Blood Institute (NHLBI) Recipient Epidemiology and Donor Evaluation Study–III (REDS-III) (2015). Oral iron supplementation after blood donation: a randomized clinical trial. *JAMA*, *313*(6), 575–583. https://doi.org/10.1001/jama.2015.119
26. Li, W., Su, C. Y., Meulenbeld, A., Jagirdar, H., Janssen, M. P., Swanevelder, R., Bruhn, R., Kaidarova, Z., Bravo, M. D., Cao, S., Custer, B., van den Berg, K., & Russell, W. A. (2025). Machine-learning models to predict iron recovery after blood donation: a model development and external validation study. *The Lancet. Haematology*, *12*(6), e431–e441. https://doi.org/10.1016/S2352-3026(25)00068-7
27. Vassallo, R. R., Hilton, J. F., Bravo, M. D., Vittinghoff, E., Custer, B., & Kamel, H. (2020). Recovery of Iron Stores After Adolescents Donate Blood. *Pediatrics*, *146*(1), e20193316. https://doi.org/10.1542/peds.2019-3316
28. Saunders, P. U., Garvican-Lewis, L. A., Schmidt, W. F., & Gore, C. J. (2013). Relationship between changes in haemoglobin mass and maximal oxygen uptake after hypoxic exposure. *British journal of sports medicine*, *47 Suppl 1*(Suppl 1), i26–i30. https://doi.org/10.1136/bjsports-2013-092841
29. Pedini, P., Baudey, J. B., Pouymayou, K., Falaise, C., Ibrahim-Kosta, M., Vélier, M., Demerle, C., Graiet, H., Dragutini, C., Dombey, A. M., Chiaroni, J., Alessi, M. C., & Picard, C. (2022). Screening platelet function in blood donors. *Transfusion*, *62*(8), 1643–1651. https://doi.org/10.1111/trf.16990
30. Saltzmann C. (2023). How to convert whole-blood donors to plasma donors: An investigation of the mechanisms of awareness of need for plasma and donors' perception of response efficacy. *Transfusion*, *63*(5), 1023–1043. https://doi.org/10.1111/trf.17316