Effect of High-intensity Interval Training on Functional Capacity in Anemic Patients with Splenomegaly

Arsanious Milad Fahmy Shenouda[1*], Azza Abd El Aziz Abd El Hady[2], Neemat Mohamed Aly Kassem[3], Ramy Salama Atia Draz[2]

[1] Department of Physical Therapy, Family Medicine Center in Manil Shiha, Abu Nomros Medical Administration, Giza Health Directorate, Giza, Egypt,

[2] Department of Physical Therapy for Cardiovascular/Respiratory Disorder and Geriatrics, Faculty of Physical Therapy, Cairo University, Giza, Egypt,

[3] Department of Clinical Pathology, Faculty of Medicine, Cairo University, Giza, Egypt

Email: arsanyaa@gmail.com, **Mobile:** +201273726377

Abstract

Background: Anemia in patients with splenomegaly reduces functional ability/capacity and impairs activities of daily living (ADL), which lowers the patient's quality of life and raises their mortality risks. ***Aim of study:*** Assessing the impact of high-intensity interval training (HIIT) on functional ability/capacity in splenomegaly anemic patients. ***Setting:*** Hematology Unit, Department of Internal Medicine, Cairo University Hospitals (Al-Kasr Al Aini). ***Design:*** This randomized controlled HIIT trial was conducted on 50 anemic men with splenomegaly. ***Subjects:*** Fifty men suffering from splenomegaly-induced anemia, with ages ranging from 30 to 45 years old, were included. Patients were randomly and equally assigned into 2 groups: a control group and a study group, n = 25 patients for each group. The control group received their medications for 14 weeks in addition to a well-balanced diet, while the study group received the same treatment protocol as the control group in addition to HIIT on a bicycle ergometer three times per week with a total duration of 30-40 minutes per session. ***Tools:*** Before and after 14 weeks, a six-minute walk test (6MWT; as a measure for patients' functional capacity), red blood cells (RBCs), hemoglobin (Hb), and Katz Index of Independence in ADL were assessed. ***Results:*** Within-group comparison of outcomes showed a significant improvement in the RBCs, Hb, 6MWT, and Katz Index of Independence in both groups but the improvements within the study group were higher than the control group. Between-group comparison of post-values of outcomes showed a significant improvement in the assessed outcomes in the direction of the study group. ***Conclusion:*** It could be concluded from this trial that HIIT safely improves functional capacity, RBCS, Hb, and performance of ADL in anemic patients with splenomegaly. ***Recommendations:*** It is recommended to incorporate HIIT on a bicycle ergometer three times weekly for 30-40 minutes per session in the treatment protocol for anemic patients with splenomegaly.

Keywords: High-intensity interval training; Functional capacity; Hemoglobin; Anemia; Splenomegaly

Receive Date: 20/7/2024	Accept Date: 1/8/2024	Publish Date: 1/1/2025

Introduction

The spleen is the main large organ of the body involved in the regulation of immune functions (these functions include stimulating immune responses and removing antigens and foreign bodies), homeostasis of red blood cells (RBCs), and recycling of iron in the blood [1].

Print ISSN 2636-3224
Online ISSN 2636-3232

In different pathological hematological disorders, the spleen can be stimulated/forced to regain low hematopoietic functions, and rebuilding these functions is usually accompanied by splenomegaly [2].

One of these hematological disorders is anemia, a decrease in the count of RBCs, erythrocyte formation, or both. Anemia, especially long-duration anemia [3] and macrocytic anemia (macrocytic anemia is mainly induced by vitamin B9 and vitamin B12 deficiencies) [4], can induce splenomegaly that negatively affects spleen-regulating immune responses (anemia may inhibit T-cell proliferation and macrophage functions), homeostasis of RBCs, and recycling of iron in the blood [3].

Besides irritating symptoms (early satiety, diaphragmatic irritation, abdominal discomfort, pain, or both and elevated inactivity), splenomegaly can negatively impact anemic patients' quality of life, physical capacity, autonomous performance of activities of daily living (ADL) [5].

Optional therapeutic procedures for splenomegaly are limited to the following categories/options: treating the underlying condition/disorder (such as hematological disorders), spleen reduction therapies, or surgical removal of the spleen [6].

Besides medications and a well-balanced diet, regular exercise is one of the main complementary treatments for anemia and anemia-induced splenomegaly. Regular exercise increases the blood volume and the amount of hemoglobin (Hb) and RBCs. Research indicated that the improvement in RBCs, Hb, and blood volume depends on the applied exercise's type, intensity, and duration [7].

High-intensity interval training (HIIT) – a type of exercise that contains short periods of vigorous/strenuous activity interrupted/separated by periods of low-intensity for-recovery exercise performance – proved its ability to improve cardiorespiratory fitness, physical capacity, quality of life, metabolic functions [8-11], blood volume, functions of erythrocyte system, number of RBCs, content of Hb, and oxygen carrying capacity of the blood [12].

The studies that assessed the effect of HIIT on RBCs, Hb, functional/physical capacity, and performance of ADL in anemic patients with splenomegaly are very limited. Hence, this study's authors aimed to investigate this effect.

Print ISSN 2636-3224
Online ISSN 2636-3232

Materials and methods

Design

This randomized controlled HIIT trial was conducted on 50 anemic men with splenomegaly.

Settings

Men were recruited from the Hematology Unit, Department of Internal Medicine, Cairo University Hospitals (Al-Kasr Al Aini).

Ethics

The protocol of this HIIT study was approved by the Research Ethics Committee, Faculty of Physical Therapy, Cairo University (PT/REC/012/004214) on 13 November 2022. A written signed consent was gathered from 50 anemic men with splenomegaly. The principles of the Helsinki Declaration were followed.

Inclusion criteria

The age of the included 50 anemic men with splenomegaly ranged from 35 to 45 years old. All men were anemia (moderate type anemia induced by splenomegaly).

Exclusion criteria

Authors excluded from this HIIT study any suffering from musculoskeletal pain/deformity in the lower limb, respiratory/cardiac diseases, kidney/liver diseases, severe anemia, psychological disorders, current smoking, hypertension, and abnormal glucose metabolism. Besides autoimmune diseases, patients with recent participation in exercise programs were also excluded.

Randomization

Via the enclosed envelope technique, fifty men with splenomegaly-induced anemia were randomly and equally assigned into two interventional groups, the study or control group. Both groups of men with splenomegaly-induced anemia received their medications and well-balanced diet. Only men in the study group additionally received HIIT on a bicycle ergometer three times weekly (the total duration of HIIT session was 30-40 minutes) **(Figure 1)**.

Print ISSN 2636-3224
Online ISSN 2636-3232

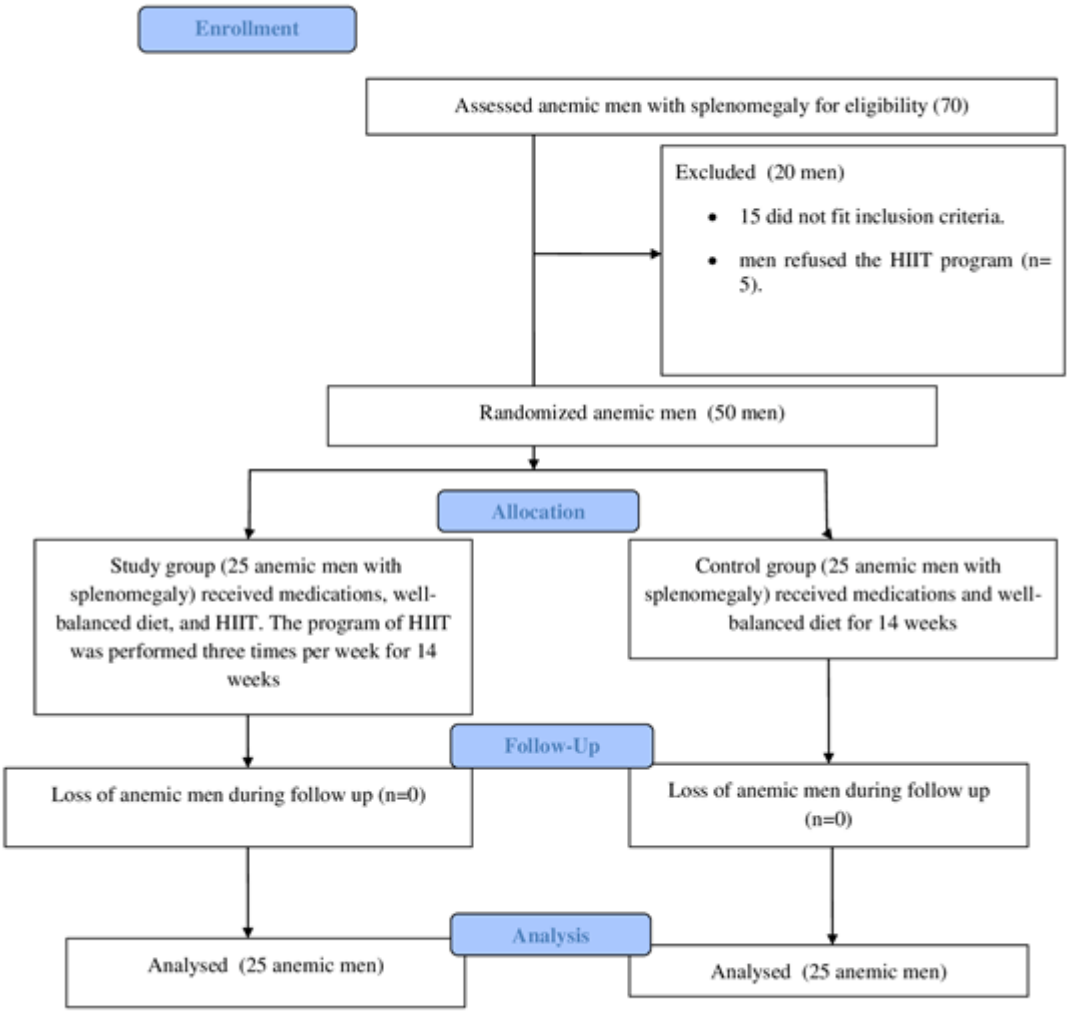

Figure 1. Study flow chart.

Program of HIIT

Before starting the first session of 14-week HIIT for the study group's men with splenomegaly-induced anemia, a maximal exercise test was a fundamental test that was performed with progressive/gradual elevated workloads up to the maximally tolerated perception of fatigue, tiredness, and breathlessness-induced by patients' exhausted or limited capacity/adaptation of the cardiovascular system.

The load during every HIIT session was detected according to anemic men's heart rate reserve (HRR), which was gained from an equation that subtracted anemic men's maximal heart rate (MHR) from their resting heart rate (RHR). Before starting every HIIT session, without taking food/meals for 2 hours before the designed session, patients were ordered to sit on the bicycle ergometer to perform 5-minute warming-up bicycling at 15-20% of anemic men's MHR)

Print ISSN 2636-3224
Online ISSN 2636-3232

without applied resistance/load from the bicycle ergometer. After performing the warming up, HIIT was conducted for 3-5 minutes at 85- 95% of anemic men's MHR, then an interval period of continuous bicycling for 10-12 min was performed at 60-75% of anemic patients' MHR for 20 to 30 minutes. At the end of every HIIT, similar to the warming-up procedure, a 5-minute cooling down was performed. The total duration of the conducted exercise session was 30-40 minutes [13].

Interventions

Six-minute walk test

The functional capacity of all men with splenomegaly-induced anemia was assessed via a six-minute walk test (6MWT, the distance covered by anemic men during six-minute walking on a 30-meter corridor.

Red blood cells and hemoglobin

After overnight fasting, a 5-ml venous blood sample was gained from men with splenomegaly-induced anemia. A blood analyzer (Mispa count, made in Germany) was used to assess men's RBCs and Hb.

Katz Index of Independence in Activities of Daily Living (Katz ADL)

Katz ADL is the best valid tool for determining patients' functional status, which measures/assesses the patients' capacity for autonomous performance and execution of daily tasks/activities. This tool, Katz ADL, is usually used by clinicians and healthcare professionals to identify issues/problems with executing activities of daily living (ADL) and to design a treatment plan accordingly. Adequacy of ADLI-related performance in the common six areas/domains of toileting, dressing, transferring, eating, and bathing is ranked/graded by the Katz ADL. Regarding the independent performance in each of the six ADL functions, clients receive a "yes" or "no score". A score of two or fewer indicates severe functional impairment in ADL performance, a score of "four" suggests moderate impairment in ADL performance, and a score of "six" shows complete independence in the performance of ADL [14].

Blinding

The assessors of 6MWT, red blood cells, hemoglobin, and Katz ADL in groups of splenomegaly-induced anemia did not know the nature of applied interventions (mediations, well-balanced diet, and HIIT).

Statistical analysis

Besides the outcomes (6MWT, red blood cells, hemoglobin, and Katz ADL), anemic men's demographic data such as body mass index (BMI) and age were normally distributed, hence unpaired and paired tests. The paired test was used to analyze within-group data, and the other was used to analyze between-group data using SPSS 24.

Print ISSN 2636-3224
Online ISSN 2636-3232

Results

Before starting this HIIT trial, no significant difference (P > 0.05) was reported after the assigned between-group comparison of anemic men's demographic data **(Table 1)** and outcomes (RBCs, Hb, 6MWT, and ADL) **(Table 2)**.

After ending this HIIT trial, a within-group comparison of anemic men's outcomes showed a significant improvement in RBCs, Hb, 6MWT, and Katz ADL) in both groups, but the improvements within the study group (the group of anemic men with splenomegaly who received HIIT) were higher than the anemic control group **(Table 2)**.

After ending this HIIT trial, the between-group comparison of anemic men's post-values of outcomes (RBCs, Hb, 6MWT, and Katz ADL) showed a significant improvement in the assessed outcomes in the direction of the study group (the group of anemic men with splenomegaly who received HIIT) **(Table 2)**.

Table 1. Comparison of pre-treatment age and BMI between anemic men groups.

Anemic men's demographics		Control group (N = 25)	Study group (N = 25)	P-value
Age (years)	**Mean**	40.12	41.08	0.259^{NS}
	±SD	2.83	3.10	
BMI (Kg/m^2)	**Mean**	23.91	23.77	0.851^{NS}
	±SD	2.70	2.72	

T: independent sample T-test; NS: Non-significant; SD: Standard deviation; BMI: body mass index

Print ISSN 2636-3224
Online ISSN 2636-3232

Table 2. Outcomes of anemic men with splenomegaly.

Anemic men's pre- and post-outcomes	Control group	Study group	P value (between anemic groups)
Six-minute walk test (meter)	**Mean±SD**	**Mean±SD**	
Before HIIT	402.8±11.3	404±25.2	0.816
After HIIT	424.9±24.3	625.8±121.8	<0.001^{HS}
P value (within anemic groups)	<0.001^{HS}	<0.001^{HS}	
Red blood cells (L)	**Mean±SD**	**Mean±SD**	
Before HIIT	3.7±0.49	3.9±0.47	0.189^{NS}
After HIIT	4.08±0.58	4.61±0.54	0.001^{S}
P value (within anemic groups)	0.044^{S}	<0.001^{HS}	
Hemoglobin (g/dL)	**Mean±SD**	**Mean±SD**	
Before HIIT	8.76±0.57	8.84±0.65	0.622^{NS}
After HIIT	9.29±0.90	10.70±1.02	< 0.001^{HS}
P value (within anemic groups)	0.009^{S}	<0.001^{HS}	
Katz Index of Independence in ADL	**Mean±SD**	**Mean±SD**	
Before HIIT	3.00±1.39	3.07±1.57	0.863^{NS}
After HIIT	4.27±1.70	5.20±1.21	0.017^{S}
P value (within anemic groups)	0.003^{S}	<0.001^{HS}	

NS: Non-significant; SD: Standard deviation; S: Significant; ADL: Activities of daily living; HS: Highly significant.

Discussion

This study proved the positive role of 14-week HIIT in improving RBCs, Hb, functional capacity, and performance of ADL in anemic patients with splenomegaly.

The rationale of HIIT-induced improvement in the assessed outcomes may be related to exercise-induced improvement in the hematopoietic microenvironment that stimulates the bone marrow to accelerate the process of erythropoiesis (formation of erythrocytes) that increases the count of RBCs and Hb content in patients' blood [15].

Exercise increases blood flow/volume and tissue perfusion to the working peripheral skeletal muscles [16] and may increase the mechanical and shear stresses on RBCs in the exercised subject's bloodstream. These stressors modulate blood rheology, RBC properties, or both such as the increased ability of RBCs to pass through small capillaries to supply working muscles with the needed oxygen to prevent/delay fatigue perception [17]. Hence the patient reports an improvement in their functional capacity and physical performance during different daily tasks and ADL.

The results of RBCs and HD after HIIT in this trial were supported by Kassab and Gaber[12], who reported an improvement in anemic women's RBCs and Hb after 8-week HIIT. Also, the presented results of Hb in this HIIT trial agreed with the results of the study conducted by Hu and Lin [15], who related the exercise-

Print ISSN 2636-3224
Online ISSN 2636-3232

induced increase in Hb to the increased expression of erythropoietin receptors responsible for the process of erythropoiesis in the bone marrow .

The study performed by Putra et al. [18] supported the presented results in this paper because they affirmed a significant improvement in Hb, RBCs, the maximal volume of oxygen consumption (VO2max, an indicator for the subject's status of functional capacity) after 8-weeks HIIT. Also, another HIIT study supported the presented results, especially after the reported significant improvement in RBCs and Hb that was gained after adding 6-week HIIT to the consumption of omega-3 supplements in sedentary boys [19].

Again, in a study published in 2016, the excessive oxygen demand during HIIT that induced the production/release of erythropoietin hormone (this hormone stimulates the production/synthesis of RBCs and Hb) may be the cause of the significant increase of RBCs and Hb after 8-week HIIT in young girls [20]. Another study published in 2022 [21] reported that high-intensity one-bout cycling (four sets of rope jumping exercises conducted at maximum power/force for 30 seconds) significantly increased the levels of RBCs and Hb in obese adolescent boys with hemolytic anemia; hence, their results were parallel to our results.

On the other side, the results of Hb and RBCs were not compatible with those of Ahmadi and Abdiyan [22], who reported that different intensities of HIIT did not change RBCs and Hb in overweight and obese subjects (may be due to the different gender of the included participants in their study. Also, all participants in their study were females and some of them were obese). Also, another study opposed our Hb and RBCs results because it reported a significant decrease of both measures in sedentary obese men, which may be due to the short duration of the applied HIIT program (the duration of the program was 6 weeks only) [23].

Regarding the improved 6MWT in this study, the studies that assessed the effect of HIIT on 6MWT in anemic patients are very limited. The results gained from the study published by Musonda et al. [24] supported our results because the authors reported an increase in chronic heart failure patients' oxygen saturation and 6MWT (the test of cardiopulmonary capacity) after the regular performance of 12-week HIIT. Also, the systematic review published by Goberdhan et al. [25] supported the results of 6MWT of our trial because it reported a significant improvement in chronic heart failure patients' functional capacity (assessed via 6MWT) after the regular engagement of those patients in HIIT programs.

Regarding the results of improved Katz ADL, a study published in 2014 was compatible with our results of Katz ADL because it reported an improvement in Katz ADL after HIIT in patients with Parkinson's disease. The study related this improvement to the enhanced motor functions, mass of skeletal muscle mass, functions of mitochondria, and physical capacity of the participants of Parkinson's disease [26]. Also, our results of Katz ADL agreed with the results of

Print ISSN 2636-3224
Online ISSN 2636-3232

Rivas-Campo et al. [27], who showed a significant improvement in Katz ADL and physical/functional capacity after engaging older patients with mild cognitive impairment in the HIIT program. Again, the results of a recent systematic review recommended using HIIT to enhance motor functions and ADL in a different category of patients (patients with mild dementia) [28].

On the other side, this may be due to the different categories of patients, a systematic review opposed our results because it reported an insignificant effect of HIIT in improving ADL in patients with dementia [29]. Also, the results of a systematic review analyzed the results of exercise program conducted on community-dwelling people with dementia opposed our results because the systematic review reported no significant improvement in ADL after exercise rehabilitation may be due to the different age classes of the exercised patients in this systematic review [30].

Conclusion

A 14-week HIIT significantly improved 6MWT, RBCs, Hb, and Katz ADL in anemic men with splenomegaly.

Limitations

Tracking the post-HIIT values of 6MWT, RBCs, Hb, and Katz ADL was the main shortage of this study that must be covered in future trials.

Acknowledgment

All the participants have our deepest gratitude and appreciation. We express our genuine gratitude to EdigenomiX Scientific Co., Ltd. for their proficient services, which significantly enhanced the lucidity and excellence of our article. We greatly applaud their fastidious attention to detail and assistance in revising the paper for publication.

Authors' contributions

Azza Abd El Aziz Abd El Hady, Neemat Mohamed Aly Kassem, and Ramy Salama Atia Draz designed the study; Arsanious Milad Fahmy Shenouda collected the samples and clinicopathological data; Arsanious Milad Fahmy Shenouda, Azza Abd El Aziz Abd El Hady, Neemat Mohamed Aly Kassem, and Ramy Salama Atia Draz conducted experiments and the data analysis; Arsanious Milad Fahmy Shenouda, Azza Abd El Aziz Abd El Hady, Neemat Mohamed Aly Kassem, and Ramy Salama Atia Draz have contributed to the writing of the manuscript; and all authors share and approved the final version.

Funding

No finding.

Print ISSN 2636-3224
Online ISSN 2636-3232

Availability of data and material

The data are available upon request.

Consent for publication

Not applicable.

Conflict of interest

No conflicts of interest.

References

1. Chadburn A. The spleen: anatomy and anatomical function. Semin Hematol. 2000; 37: 13-21.

2. Wei YH, He YZ, Guo XY, Lin XY, Zhu HB, Guo XJ. Investigation and Analysis of Iron-Deficiency Anemia Complicated by Splenomegaly. Int J Gen Med. 2021; 14: 4155-9.

3. Li Y, Yue H, Yang S, Yuan D, Li L, Zhao J, et al. Splenomegaly induced by anemia impairs T cell movement in the spleen partially via EPO. Mol Immunol. 2019; 112: 399-405.

4. Lordi A, Ansari N, Maroules M, Manjegowda A. Splenomegaly in a Patient with a History of Pernicious Anemia; the Potential Therapeutic Effects of B12 Therapy. Case Reports in Hematology. 2022; 2022: 1-3.

5. Mesa RA, Schwager S, Radia D, Cheville A, Hussein K, Niblack J, et al. The Myelofibrosis Symptom Assessment Form (MFSAF): an evidence-based brief inventory to measure quality of life and symptomatic response to treatment in myelofibrosis. Leuk Res. 2009; 33: 1199-203.

6. McKenzie CV, Colonne CK, Yeo JH, Fraser ST. Splenomegaly: Pathophysiological bases and therapeutic options. Int J Biochem Cell Biol. 2018; 94: 40-3.

7. Cicek G. The Effects of Different Exercise Types on Hematological Parameters in Sedentary Women. Journal of Education and Training Studies. 2018; 6: 96.

8. Feito Y, Heinrich KM, Butcher SJ, Poston WSC. High-Intensity Functional Training (HIFT): Definition and Research Implications for Improved Fitness. Sports (Basel). 2018; 6.

9. Ismail AMA. Metabolic syndrome components response to the conducted 16-week randomised-controlled training trial on an elliptical trainer. Eur J Physiother. 2023; 25: 147-53.

10. Ismail AMA, Abdelghany AI. Effect of Adding a 2-Month Consequent Continuous and Interval Elliptical Aerobic Training to Once-Daily 5-mg Tadalafil Administration on Erectile Dysfunction in Obese Men. Sexuality and Disability. 2022; 40: 129-39.

11. Ismail AMA, El-Azeim ASA, Saif HFAEA. Effect of aerobic exercise alone or combined with Mediterranean diet on dry eye in obese hypertensive elderly. Ir J Med Sci. 2023; 192: 3151-61.

12. Kassab ABN, Gaber AA. Effect of High Intensity Interval Training on Serum Ferritin and Haematological Parameters in Anaemic Women: A Prospective Randomized Clinical Trial. World Journal of Medical Sciences. 2019; 6: 70-4.

13. Hebisz P, Cortis C, Hebisz R. Acute Effects of Sprint Interval Training and Chronic Effects of Polarized Training (Sprint Interval Training, High Intensity Interval Training, and Endurance

Print ISSN 2636-3224
Online ISSN 2636-3232

Training) on Choice Reaction Time in Mountain Bike Cyclists. Int J Environ Res Public Health. 2022; 19.

14. Shelkey M, Wallace M. Katz index of independence in activities of daily living (ADL). Int J Older People Nurs. 2012; 2: 204-12.

15. Hu M, Lin W. Effects of exercise training on red blood cell production: implications for anemia. Acta Haematol. 2012; 127: 156-64.

16. Gliemann L, Hansen CV, Rytter N, Hellsten Y. Regulation of skeletal muscle blood flow during exercise. Curr Opin Physiol 2019; 10: 146-55.

17. Nemkov T, Skinner SC, Nader E, Stefanoni D, Robert M, Cendali F, et al. Acute Cycling Exercise Induces Changes in Red Blood Cell Deformability and Membrane Lipid Remodeling. Int J Mol Sci. 2021; 22.

18. Putra KP, Al Ardha MA, Kinasih A, Aji RS. Korelasi perubahan nilai VO2max, eritrosit, hemoglobin dan hematokrit setelah latihan high intensity interval training. Jurnal Keolahragaan. 2017; 5: 161-70.

19. karimi pour s, Nayebifar S. The Response of Some of Hematological Indicators to 6-Week High-Intensity Interval Training along With Omega-3 Supplement Intake in Sedentary Boys. Sci J Kurdistan Univ Med Sci. 2020; 25: 61-72.

20. Khoshnam MS, Khoshnam E, KOUSHKI JM, Karampour E. The Effects Of Eight Weeks Of High Intensity Interval Training And Hypoxia High Intensity Interval Training On Blood Index Young Girls. Iranian International Conference on Women's Health. 2016.

21. TaheriChadorneshin H, Nazari S. The Impact of Rope Jump Exercise Training on Hemolytic Anemia Parameters in Obese Adolescent Boys. Zahedan J Res Med Sci. 2022; 24: e106947.

22. Ahmadi A, Abdiyan RD. Compare the effects of two high intense interval training (HIIT) protocol on some hem rheological markers in young overweight and obese women. Alborz University Medical Journal. 2017; 6: 211-8.

23. Gharari Arefi R, Chubineh S, Kordi MR. The effect of a high-intensity interval training on some of factors affecting erythrocyte sedimentation rate in sedentary young men. Journal of Practical Studies of Biosciences in Sport. 2016; 3: 74-83.

24. Musonda MM, Nkhata Loveness A, Goma Fastone M. Effects of High-Intensity Aerobic Interval Training on Cardiopulmonary Function in Patients With Chronic Heart Failure at The University Teaching Hospital, Lusaka, Zambia. Journal of Agriculture and Biomedical Sciences–JABS. 2022; 6.

25. Goberdhan C, Sairras S, Van Der Hilst K, Baldew S. Using the 6-minute walking test to evaluate the effect of high-intensity interval training on the functional capacity in heart failure patients: a systematic review and meta-analysis. Eur Heart J. 2022; 43: ehac544. 989.

26. Kelly NA, Ford MP, Standaert DG, Watts RL, Bickel CS, Moellering DR, et al. Novel, high-intensity exercise prescription improves muscle mass, mitochondrial function, and physical capacity in individuals with Parkinson's disease. J Appl Physiol. 2014; 116: 582-92.

27. Rivas-Campo Y, Aibar-Almazán A, Afanador-Restrepo DF, García-Garro PA, Vega-Ávila GC, Rodríguez-López C, et al. Effects of High-Intensity Functional Training (HIFT) on the Functional Capacity, Frailty, and Physical Condition of Older Adults with Mild Cognitive Impairment: A Blind Randomized Controlled Clinical Trial. Life. 2023; 13: 1224.

Print ISSN 2636-3224
Online ISSN 2636-3232

28. Yeh SW, Lin LF, Chen HC, Huang LK, Hu CJ, Tam KW, et al. High-intensity functional exercise in older adults with dementia: A systematic review and meta-analysis. Clin Rehabil. 2021; 35: 169-81.

29. Russ J, Weyh C, Pilat C. High-intensity exercise programs in people with dementia — a systematic review and meta-analysis. Ger J Exerc Sport Res 2021; 51: 4-16.

30. Steichele K, Keefer A, Dietzel N, Graessel E, Prokosch HU, Kolominsky-Rabas PL. The effects of exercise programs on cognition, activities of daily living, and neuropsychiatric symptoms in community-dwelling people with dementia-a systematic review. Alzheimers Res Ther. 2022; 14: 97.

Print ISSN 2636-3224
Online ISSN 2636-3232