Original Article

Impact of Physical Activity Intervention on Hemoglobin Levels: A Controlled Comparative Study

Reeshma EK[1], Archana Mukunda[2], Sheeba Varghese[3], Anjanakrishna[4], Divya R[5], Kavya Krishna[6]

[1]Assisstant Professor, Department of Physiology, Royal Dental College, Palakkad, Kerala
[2]Professor, Department of Oral Pathology, Royal Dental College, Palakkad, Kerala
[3]Professor& HOD, Department of Physiology, Royal Dental College, Palakkad, Kerala
[4]Reader, Department of Physiology, PMS Dental College, Trivandrum, Kerala
[5]Reader, Department of Oral Pathology, Royal Dental College, Palakkad, Kerala
[6]Lecturer, Department of Anatomy, Royal Dental College, Palakkad, Kerala
Corresponding Author: Reeshma EK, Assistant Professor, Royal Dental College, Palakkad, Kerala

Abstract **Background:** Hemoglobin (Hb) plays a critical role in oxygen transport and is essential for maintaining normal physiological functions and physical performance. Physical activity is known to induce hematological adaptations that may improve hemoglobin levels and overall health status.

Aim: To evaluate the effect of a structured physical activity intervention on hemoglobin levels among young adults.

Materials and Methods: This prospective interventional study was conducted among 60 healthy participants aged 18–25 years. Participants were divided into two groups: Group 1 (control, n=30) and Group 2 (physical activity intervention, n=30). The intervention group participated in supervised moderate-intensity aerobic exercises, including jumping, skipping, and squatting, for 30 minutes per day, five days per week for 12 weeks, while the control group maintained their usual lifestyle. Venous blood samples were collected before and after the intervention period, and hemoglobin concentration was measured using an automated hematology analyzer. Data were analyzed using SPSS version 26.0. Paired t-test and independent sample t-test were applied, with $p<0.05$ considered statistically significant.

Result: The mean Hb level in the control group remained unchanged from baseline (13.94 ± 1.36 g/d) to post-intervention (13.94 ± 1.30 g/dL) ($p=0.914$). In contrast, the intervention group demonstrated a significant increase in mean Hb level from 13.16 ± 1.42 g/dL to 14.52 ± 1.36 g/dL following the intervention ($p<0.001$). The findings indicate that regular physical activity significantly improved hemoglobin concentration.

Conclusion: Structured moderate-intensity physical activity significantly enhances hemoglobin levels in young adults and may serve as an effective non-pharmacological strategy for improving hematological health and oxygen-carrying capacity.

Keywords: Exercise, Hematological Health, Hemoglobin, Physical Activity, Young Adults

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INTRODUCTION

Hemoglobin is an essential protein found in red blood cells that is responsible for the transport of oxygen from the lungs to body tissues and the return of carbon dioxide to the lungs for exhalation.

Adequate hemoglobin levels are necessary for maintaining normal physiological functions, physical performance, and overall health.[1] Low hemoglobin levels can result in anemia, a condition associated with fatigue, reduced exercise tolerance, impaired cognitive function, and decreased quality of life.

Anemia remains a significant public health concern, particularly among adolescents, women of reproductive age, and individuals with inadequate nutritional intake.[2] Physical activity is recognized as an important determinant of health and well-being. Regular physical activity contributes to improved cardiovascular fitness, enhanced metabolic function, better body composition, and reduced risk of chronic diseases.[3] Exercise influences the hematological status of the individual and hematological status and is dependent on type, duration and intensity of the exercise.[4] Regular physical activity has been shown to positively affect hemoglobin levels. As the body engages in exercise, oxygen demand increases in active tissues, which leads to physiological adaptations, including an increase in erythropoiesis (red blood cell production). This adaptation is necessary to meet the body's heightened oxygen requirements during physical exertion. Aerobic exercise, such as jogging, has been linked to an increase in blood volume and hemoglobin concentration, as consistent exercise combined with proper nutrition supports enhanced oxygen delivery.[5] The present study was undertaken to compare hemoglobin levels and physical activity outcomes between a control group and a physical activity intervention group. By evaluating changes before and after the intervention, the study aims to determine whether participation in a structured physical activity program can significantly improve hemoglobin levels and physical activity status. The findings may provide valuable evidence regarding the role of physical activity as a non-pharmacological strategy for promoting hematological health and overall well-being.

MATERIAL AND METHODS

The present study was a prospective interventional study conducted to assess the impact of physical activity on the hemoglobin levels in young adults. The study was conducted after obtained ethical clearance from the Institution. The study abided by the local and global ethical guidelines. The study was conducted over a period of 6 months from Feb to July 2025. The total participants of the study were 60 and they were divided into 2 equal groups comprising of 30 students in both groups. All participants who were active and willing and provided written consent, in the age range of 18-25yrs of both genders, individuals with baseline hemoglobin levels within normal range and who are fit to participate in moderate physical activity and participants who are not currently enrolled for any exercise or fitness program. Whereas, unwilling participants above the age of 25yrs and below 18yrs, participants with hemoglobin disorder like anemia and thalassemia, chronic systemic diseases, participants who are receiving iron supplementation or medication affecting hemoglobin levels, pregnant and lactating women and participants who failed to comply with the intervention or who missed interventions were excluded from the study.

Group 1: comprised of 30 control participants without any intervention

Group 2: comprised of 30 participants with physical activity intervention

Participants in the Group 1 were instructed to maintain their usual lifestyle and were not provided with any structured exercise program during the study period. The participants of Group 2 underwent a structured physical activity program consisting of moderate-intensity aerobic exercises such as aerobic exercises like jumping, skipping, squatting for 30min/day, 5 times a week which was monitored under supervision for 12 weeks. 5ml of venous blood was collected from participants of both group before starting the intervention and after the end of the intervention period (after 12weeks). The collected blood was transferred to containers with EDTA and centrifuged at 3000 RPM. The plasma obtained was measured for hemoglobin concentration using an automated hematology analyzer. (XR-Series Model; Sysmex Corporation) according to standard procedures. The values obtained were recorded as grams/ deciliter (g/dl).

Outcome measures

The primary outcome measure was the change in

hemoglobin concentration from baseline to post intervention. The secondary outcomes noted were comparison of pre and post intervention hemoglobin level in both groups as well as comparison of post intervention hemoglobin level was between controls (Group 1) and intervention group (Group 2). The values obtained were entered numerically into excel sheets and analyzed using SPSS version 26.0. the descriptive statistics were expressed as mean ± standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. Paired t-test was used to compare pre- and post-intervention hemoglobin levels within each group. Independent sample t-test was employed to compare mean hemoglobin levels between the intervention and control groups. A p-value less than 0.05 was considered statistically significant.

RESULTS

The descriptive statistics showed the mean score in Group 1 was 13.94 ± 1.36 before treatment and 13.94 ± 1.30 after treatment, demonstrating no appreciable change. The mean score for Group 2 increased from 13.16 ± 1.42 before treatment to 14.52 ± 1.36 after treatment. Paired sample t-test analysis revealed no significant difference in control group values ($p = 0.914$), whereas intervention group values showed a statistically significant increase following treatment ($p < 0.001$). These findings suggest that the intervention significantly affected intervention group but not control group. (Table 1)

	N	Range	Min	Max	Mean	Std. Error	Std. Dev
Group 1 before	30	4.50	12.00	16.50	13.9423	.13298	1.35616
Group 1 after	30	4.40	12.00	16.40	13.9365	.12705	1.29570
Group 2 before	30	5.60	10.80	16.40	13.1644	.13894	1.41695
Group 2 after	30	6.30	11.50	17.80	14.5221	.13326	1.35904

Table 1: Descriptive statistics of the study variables relating to Hb content among the four groups

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Group 1 Before-After	.00577	.54306	.05325	-.09984	.11138	.108	29	.914
Group 2 Before- After	-1.35769	.99540	.09761	-1.55127	-1.16411	-13.910	29	**.000****

Table 2: Paired sample t-test statistics of Hb content in control and test group before and after physical activity

A paired sample t-test was performed to compare the pre-treatment and post-treatment values of Group 1 and Group 2. For PL, the mean difference between the pre- and post-
treatment measurements was 0.00577 ± 0.54306. The analysis revealed no statistically significant difference between the two time points ($t = 0.108$, $df = 29$, $p = 0.914$). The 95% confidence interval for the mean difference ranged from −0.09984 to 0.11138, indicating that the intervention did not produce a significant change in PL. For PA, the mean difference between the pre- and post-treatment measurements was −1.35769 ± 0.99540. A highly statistically significant difference was observed

between the two time points ($t = -13.910$, $df = 29$, $p < 0.001$). The 95% confidence interval for the mean difference ranged from −1.55127 to −1.16411. These findings indicate a significant increase in PA after treatment. (Table 2) The physical activity intervention produced no significant change in PL ($p = 0.914$). However, PA demonstrated a statistically significant improvement following treatment ($p < 0.001$), suggesting that the treatment had a substantial effect on this parameter. The narrow confidence interval and large t-value further support the robustness of this finding.

DISCUSSION

Blood is an important medium of exchange of many substances in the body and has served in various diagnostic purposes due to its various compositions. Hemoglobin is a polyfunctional molecule which is involved in several functions such as metabolism, catalytic activity, pH regulation and maintains redox balance. The primary function is to carry oxygen from lung to tissues and thus supports cellular respiration, energy production and regulates blood pressure. Alterations in the levels of hemoglobin leads to diseases and health risks. Numerous factors affect the level of hemoglobin like age, gender, nutrition, chronic conditions, genetics and environmental factors like altitude, pregnancy, medication and physical exercise.[6] Physical activity is universally accepted to play a substantial role in maintain health and well-being of individuals and thereby reduces the risk of disease, mortality and morbidity.[3] Exercise stimulates physiological adaptations that enhance oxygen utilization, erythropoiesis, and circulation, potentially contributing to improvements in hemoglobin levels.[7] Thus, the present study was conducted to evaluate the effect of a structured physical activity intervention on hemoglobin (Hb) levels among participants by comparing pre- and post-intervention values in both groups. At baseline, the mean Hb levels of both groups were comparable, indicating a relatively similar hematological status before the intervention. Following the intervention period, the control group showed virtually no change in Hb concentration, whereas the intervention group exhibited a significant increase in mean Hb level. This finding suggested a highly significant correlation between the two groups, suggesting that the observed improvement was attributable to the physical activity intervention rather than random variation. This finding of the study was similar to findings of Sepriadi et al 2020 who found an increase in the level of hemoglobin in individuals who jogged in contrast to participants who did not jog. They suggested that there is an interconnection between hemoglobin and physical activity. During physical activity there is a high increase in metabolic activity resulting in a decrease in pH. This causes hemoglobin to release more oxygen, then it increases oxygen delivery to the muscles. Exercise or physical activity can increase hemoglobin levels in the blood.[8] Exercise also increase the total Hb and red blood cell mass, which increases oxygen carrying capacity so that with structured exercise the hemoglobin level in the blood which functions to bind oxygen in the blood and relax it throughout the body will also increase. HU M and Lin w 2012, Sonu Choudhary et al 2012 found similar findings in their study.[9,10] Arnab Ghosh et al. (2025) reported a significant increase in hemoglobin levels following acute resistance exercise. The authors attributed this finding to enhanced blood flow between the vascular and interstitial compartments during exercise, facilitated by increased cardiovascular and respiratory activity. Exercise increases the body's oxygen demand, and the elevated hemoglobin concentration may enhance oxygen transport to working muscles. This process is closely related to maximal oxygen uptake, which reflects the maximum capacity of the cardiovascular and respiratory systems to deliver oxygen to tissues and the ability of muscles to utilize it during intense physical activity.[11]

Contrary to these, Spiropoulos et al 2003 found that the hematological parameters remain unchanged even after exercise.[12] Interestingly, Hamid Arazi et al 2011 found a decrease in the level of hemoglobin along with RBC after 3hrs of exercise and attributed this variation to gas exchange on active muscles as well as rise in coagulative and immunity factors following exercise. The decrease in serum iron is manifested more in untrained participants than trained.[13] The increase in hemoglobin levels observed in the intervention group may be explained by physiological adaptations induced by regular physical activity. Exercise stimulates erythropoiesis through enhanced oxygen demand and increased production of erythropoietin, which promotes red blood cell synthesis in the bone marrow. Regular physical activity also improves circulatory efficiency and oxygen transport capacity, leading to favorable hematological adaptations over time. These mechanisms collectively contribute to an increase in hemoglobin concentration and the oxygen-carrying capacity of blood. The absence of significant changes in the control group further strengthens the evidence that physical activity was responsible for the improvement in Hb levels. The hemoglobin levels remained stable in participants who did not undergo the intervention. Increase in hemoglobin not only increased oxygenation but also helps in reducing fatigue, enhances endurance, improved cardiac function and better functional capacity in individuals who exercise. The severity, period and frequency of exercising should be well-organized to have similar fine influence on blood biochemistry.[14] The physiological significance of hemoglobin (Hb)-mediated oxygen (O_2) transport is evident in conditions such as anemia. Here decreased Hb levels reduce exercise capacity despite compensatory elevations in cardiac output. In contrast, increased total Hb mass improves aerobic performance, underscoring the essential role of Hb in maintaining efficient oxygen transport and utilization during physical activity.[15] Several studies have demonstrated a positive association between regular physical activity and hematological health. Moderate-intensity exercise has been shown to improve blood circulation and stimulate the production of red blood cells, thereby enhancing the body's oxygen-carrying capacity. However, the magnitude of these effects may vary depending on the intensity, duration, and frequency of physical activity, as well as the characteristics of the study population. Consequently, further research is needed to understand the effectiveness of structured physical activity interventions in improving hemoglobin levels. Despite these encouraging findings, certain limitations should be considered. The study included a relatively small sample size of 30 participants per group, which may limit the generalizability of the results. Additionally, factors influencing hemoglobin levels, such as dietary iron intake, nutritional status, hydration status, and individual variations in exercise adherence, were not evaluated in detail. Future studies with larger sample sizes, longer intervention periods, and comprehensive assessment of nutritional and physiological variables would provide further insight into the relationship between physical activity and hemoglobin levels.

CONCLUSION

Structured physical activity significantly increased hemoglobin levels in the intervention group, while no significant change was observed in the control group. These findings highlight the beneficial role of regular exercise as a non-pharmacological approach to improving hematological health and overall physiological well-being.

REFERENCES

1. Okon IA, Beshel JA, Owu DU, Orie NN, Jim AE, Edet LI. Moderate aerobic exercise improves

haematological indices without altering cardio-metabolic enzyme activities in sedentary healthy young adults. BMC Sports Sci Med Rehabil. 2025 Feb 28;17(1):32. doi: 10.1186/s13102-025-01080-y.

2. Weckmann G, Kiel S, Chenot JF, Angelow A. Association of Anemia with Clinical Symptoms Commonly Attributed to Anemia-Analysis of Two Population-Based Cohorts. J Clin Med. 2023 Jan 24;12(3):921. doi: 10.3390/jcm12030921.
3. Dhuli K, Naureen Z, Medori MC, Fioretti F, Caruso P, Perrone MA et al. Physical activity for health. J Prev Med Hyg. 2022 Oct 17;63(2 Suppl 3):E150-E159. doi: 10.15167/2421-4248/jpmh2022.63.2S3.2756.
4. Ciekot-Sołtysiak M, Kusy K, Podgorski T, Pospieszna B, Zielinski J. Changes in red blood cell parameters during incremental exercise in highly trained athletes of different sport specializations. PeerJ. 2024;12:e17040.
5. Kuspriyanti NP, Fauzia SR, Rachmadhian ID. The relationship between hemoglobin levels and exercise intensity among students of the faculty of medicine Pasundan University. Science Midwifery. 2025;13(5):1457-1466.
6. Azmat J, Waseem M, Dar YF, Ambreen S. Role of hemoglobin and its impact on human health-a Narrative review. Insights- Journal of Health and rehabilitation. 2024;2(2):231-237. Doi:10.71000/ijhr130.
7. Corona LP, Andrade FCD, da Silva Alexandre T, de Brito TRP, Nunes DP, de Oliveira Duarte YA. Higher hemoglobin levels are associated with better physical performance among older adults without anemia: a longitudinal analysis. BMC Geriatr. 2022 Mar 21;22(1):233. doi: 10.1186/s12877-022-02937-4.
8. Sepriadi, Jannah K, Eldawaty. The effect of jogging exercise to improve hemoglobin levels. IOP Conf. Series: Journal of Physics: Conf. Series. 2020;1481:012028IOP. doi:10.1088/1742-6596/1481/1/012028.
9. Hu M, Lin W. Effects of exercise training on red blood cell production: implications for anemia. Acta haematologica, 2012;127(3), 156-164.
10. Choudhary S, Rajnee, Binawara BK. Effect of exercise on serum iron, blood haemoglobin and cardiac efficiency. J Postgrad Med Inst. 2012;26(1):13–6.
11. Ghosh A, Mukhopadhyay K. Acute Effect of Resistance Exercise on Hemoglobin Level (HBG) Among Physically Trained Boys. Sports Med Ther. 2025; 10(2): 027-030. doi.org/10.29328/journal.jsmt.1001093.
12. Spiropoulos K, Trakada G. Hematologic and biochemical laboratory parameters before and after a marathon race. Lung. 2003;181(2):89–95. doi.org/10.1007/s00408-003-1009-y.
13. Arazi H, Damirchi A, Mostafaloo A. Variations of hematological parameters following repeated bouts of concurrent endurance resistance exercise. J Med Sci. 2011;9(2):48–52.
14. Baltacı AK, Mogulkoc R, Ustundag B, Koç S, Ozmerdivenli R. A study on some hematological parameters and the levels of plasma proteins and serum zinc, calcium and phosphorus in young female athletes. Gazi J Phys Educ Sport Sci. 1998;3(2):21–8.
15. Berglund B, Hemmingson P. Effect of reinfusion of autologous blood on exercise performance in cross country skiers. Int J Sports Med.1987;8:231–3.doi.org/10.1055/s-2008-1025661.