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The Effect of Acute Aerobic Exercise on Selective Hematological Parameters and Oxygen Saturation in Withdrawal Heroin Addicts

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ABSTRACT

Background: Heroin is an opioid derived from morphine and is either the most often misused or the most swiftly acting opioid. Chronic administration of elevated dosages of heroin leads to the development of physical dependency.

Objective: This study aimed to examine the effectiveness of acute aerobic exercise on certain hematological markers and oxygen saturation in individuals withdrawing from heroin addiction.

Subjects and methods: The study was done on eighty men "forty heroin addicts and forty normal men (control group)", their ages ranged between 20 and 40 years old. Both groups participated in the study by doing acute aerobic exercise. They were selected from The Department of Addiction in El-Tareak Hospital.

Results: Post-study, there was a statistically significant increase in hemoglobin, hematocrit, red blood cells, platelets, white blood cells, and neutrophils in group B (non-addicts), while oxygen saturation significantly decreased. In group A (withdrawal heroin addicts), there were no statistically significant differences in any hematological parameters or oxygen saturation. Comparisons between groups showed a significant difference in platelets, favoring group B, with no significant differences in other parameters pre-study. Post-study, there were significant differences in hematocrit and platelets, both favoring group B, while other parameters showed no statistically significant differences.

Conclusion: Acute aerobic exercise resulted in a significant increase in hemoglobin, hematocrit, RBCs, platelets, WBCs, and neutrophils in non-addicts (Group B). Furthermore, post-exercise, Group B demonstrated significantly higher hematocrit and platelets compared to withdrawal heroin addicts (Group A). No significant changes were observed in group A across all parameters.

Keywords: Acute aerobic exercises, Hematological parameters, Heroin, Oxygen saturation, Addiction.

INTRODUCTION

Heroin, an opioid generated from morphine, a natural chemical taken from the seed pods of opium poppy plants grown in Southeast and Southwest Asia, Mexico, and Colombia, undergoes metabolic conversion into active morphine and mono-acetyl morphine, a less active form, within 15 to 20 minutes [(1)]. Due to its high lipid solubility, it efficiently crosses the blood-brain barrier (BBB), making it more potent than morphine [(2)].

Chronic heroin use disrupts both the innate and adaptive immune systems and impacts hematological cells essential for diagnostics. Studies show that heroin addiction alters vital and trace elements, including zinc, manganese, copper, bromine, and particularly iron, which plays a key role in tissue oxygenation and cognitive functions. Changes in iron levels may impair blood cell physiology, especially red blood cells [(2)].

Another study highlights that heroin can directly influence immune cells like lymphocytes and macrophages via opioid receptors or indirectly through the nervous system's role in immunity. Research consistently indicates that opioids, including heroin and opium, affect body systems acutely and chronically, leading to changes in electrolyte balance, serum protein profiles, and coagulation factors [(3)].

Studies have also documented significant changes in hematological parameters such as hemoglobin (Hb), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH) in heroin users. A notable decrease in markers like neutrophils, monocytes, and platelets suggests weakened immune responses [(4)].

Further research on the effects of acute physical activity on blood parameters in seven active and six inactive individuals revealed that a 10-minute cycling session at a heart rate of 150 bpm led to increased levels of leukocytes, lymphocytes, and neutrophils in active participants. Additionally, their serum iron and ferritin levels were lower than those of inactive participants [(5)].

Similarly, another study exploring the effects of running found significant increases in red blood cell count (RBC), hemoglobin, packed cell volume (PCV), and lymphocyte levels after exercise compared to pre-exercise values [(6)].

Aerobic exercise has been demonstrated to effectively diminish heroin cravings and enhance inhibitory control in heroin users [(7)].

There isn't any data regarding its acute effect on the haematological parameters, thus it would be useful to know the response of the haematological parameters

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directly following an acute aerobic exercise during the withdrawal period. To our knowledge, our study would be the first to highlight this.

SUBJECTS AND METHODS

This comparative study was conducted in The Department of Addiction at El-Tareak Hospital between March 2023 and September 2023. 80 men participated in the study who were divided into two groups: Forty heroin addicts, recruited from the Department of Addiction. Forty healthy men (non-addict control group) were selected from Youth Centers in Banha. Participants in both groups were aged between 20 and 40 years.

Inclusion criteria: Male heroin addicts in the withdrawal stage, lasting between 10 days to 2 months. Age between 20 and 40 years. Body Mass Index (BMI) of less than 40 kg/m². The sample of heroin addicts was recruited from The Department of Addiction at El-Tareak Hospital. All heroin-addict participants received medications prescribed by the medical team and were clinically and medically stable at the time of the study.

Exclusion criteria: Patients with unstable cardiovascular problems, auditory or visual impairments, peripheral vascular diseases, kidney failure, acute infections and orthopedic or neurological conditions that limit the ability to exercise.

Assessment methods

Weight and height scale: Body weight and height were measured to calculate body mass index (BMI) using the formula BMI = body weight (kg)/[height (m)]². A calibrated digital scale and stadiometer were used to ensure precise measurements.

Auto hematological analyzer: (Medonic, Swedish)**:** Complete blood count (CBC) and all hematological parameters were analyzed using a Medonic automated hematology analyzer (Model X), renowned for its high precision and reproducibility.

Tools for taking blood sample: Blood samples were collected using sterile syringes, needles, tourniquet, vacutainers, test tubes, cotton, alcohol, and gloves. Venous blood sampling followed standard aseptic techniques to ensure sample integrity and prevent contamination.

Fingertip pulse oximeter: Oxygen saturation (SpO_2) was measured at rest, during exercise, and immediately post-exercise using a fingertip pulse oximeter (Model Y, Manufacturer Z) with a measurement accuracy of ± 2%.

Intervention methods

Stationary cycle: The exercise intervention involved cycling on a stationary bike at a workload of 20 watts for five minutes as a warm-up, followed by an aerobic cycling session at 60% to 80% of the subject's maximum heart rate (MHR) for a duration of 20 minutes. During the session, oxygen saturation and heart rate were continuously monitored using a fingertip pulse oximeter and heart rate monitor to ensure safety and appropriate intensity. Post-exercise, venous blood samples were collected to measure selective hematological parameters.

Procedure: This investigation involved eighty young males. The subjects were divided into two equal groups, with forty non-addicts and forty heroin addicts. The procedures were identical, with the exception of the intensity of the exercise. The subsequent procedures were identical for both groups. Each subject's body mass index (BMI) was determined by measuring their weight and height. Prior to the exercise, a pulse oximeter was employed to measure oxygen saturation. Selective hematological parameters were assessed by collecting venous blood samples prior to exercise. Warming up exercises were implemented by each participant, which consisted of cycling on a stationary bicycle at a 20 watt workload for five minutes. Subsequently, all participants engaged in aerobic cycling exercise for 20 minutes at an intensity that ranged from 60% to 80% of their maximum heart rate. A digital monitor was used to register the heart rate during the exercise. In order to guarantee the intensity and duration of the exercise, all subjects were monitored during the exercise. Then, each subject concluded with a five-minute period of calming down. The fingertip pulse oximeter was used to manually record oxygen saturation following the exercise. After the exercise, venous blood samples were obtained to assess specific hematological parameters.

Ethical approval: The study received approval from the Ethical Committee of The Faculty of Physical Therapy, Cairo University, with the approval number P.T.REC/012/003566. The patients were informed of the study's objectives and procedures prior to their enrollment, and they provided written consents. This work has been carried out in accordance with The Code of Ethics of World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Descriptive statistic was used to determine mean and SD of the participants. Descriptive statistics and unpaired t-test were carried out for assessment of the mean age (years), weight (Kg), height (cm), and BMI (kg/m^2) of the two groups. In advance of analysis, test of Shapiro-Wilk was employed to check the data normality. Variance's homogeneity test of Leaven was performed to evaluate among groups homogeneity, which revealed normally distributed data with variance homogeneity. Boxplot showed no data outliers. MANOVA of mixed 2 x 2 design was carried out to examine the impact of treatment (between groups), time (pre versus post) besides the interaction impact on values of mean of selected hematological parameters (Hb, RBCs, HCT, PLT, WBCs and Neutrophils) and oxygen saturation The significance level for all statistical examinations appointed at $p \leq 0.05$. Version 20 of the statistical package for social studies (SPSS) for windows (IBM SPSS, Chicago, IL, USA) was employed for all statistical tests.

RESULTS

Subject characteristics: Eighty participants joined in the present study. They were allocated randomly into two groups equally. Group A (Experimental group) included 40 participants with age, weight, height, and BMI mean of 30.4±5.3 years, 72.2 ±14 kg, 173±5.4 cm and 24 ±4.1 kg/m^2 respectively. Group B (Control group) included 40 participants with age, weight, height, and BMI mean of 28.3 ±6.6 years, 77.5±16.4 kg, 174.3±6.3 cm and 25.4±4.6 kg/m^2 respectively. There were no significant differences ($p > 0.05$) in the values of mean of age, weight, height, and BMI among the two groups as specified by unpaired t-test (Table 1).

Table (1): Descriptive statistics and unpaired t-test for subject characteristics of both groups

	Group A	Group B	t-value	P-value
Age (years)	30.4 ±5.3	28.3 ±6.6	1.56	0.121
Weight (Kg)	72.2 ±14	77.5 ±16.4	-1.54	0.127
Height (cm)	173 ±5.4	174.3 ±6.3	-1.03	0.302
BMI (Kg/m^2)	24 ±4.1	25.4 ±4.6	-1.42	0.159

Significant at alpha level <0.05, N: number,
N.S.: Non-significant.

Overall effect of acute aerobic exercise on variable measuring periods and conditions for all dependent variables:

There was no statistically significant effect of the first independent variable (the examined group) on the measured variables (F=1.024, P=0.422) and there was no significant effect of the second independent variable (the measuring periods) on the examined dependent variables (F=1.59, P=0.151). Also, there was significant interaction (F=0.640, P=0.721) assessed by 2x 2 mixed MANOVA design statistical analysis (Table 2).

Table (2): 2 x2 mixed MANOVA design at variable measuring periods and conditions for all dependent variables

Variation source	F-value	P-value	η2
Groups	1.024	0.422	0.091
Measuring periods	1.59	0.151	0.134
Interaction	0.640	0.721	0.059

Significant at alpha level <0.05

Effect of acute aerobic exercise on selected hematological parameters

1- Hemoglobin: Within group comparison, the mean Hb pre- and post-study of group A was 14.26 ±1.06 and 14.28 ± 1.1 g/dl respectively, the percentage of change was 0.02%. There was no statistical significant difference between pre- and post-study in Hb in group A (p = 0.516). The mean value of Hb pre- and post-study of group B was 14.61 ± 1.10 and 14.68 ± 1.06 g/dl respectively, the percentage of change was 0.07%. There was statistical significant increase in post- study compared to pre-study in Hb in group B (p = 0.015) (Table 3).

Between groups comparison: There was no statistical significant difference in the mean values of Hb between both groups pre-study and post-study (p= 0.203 and 0.053 respectively) (Table 3).

2- Red blood cells: Within group comparison, the mean value of RBCs pre- and post-study of group A was 5.386 ± 0.474 and 5.388 ± 0.473 million/ul respectively, the percentage of change was 0.002%. There was no statistical significant difference between pre- and post-study in RBCs in group A (p = 0.933). The mean value of RBCs pre- and post-study of group B was 5.56 ± 0.51 and 5.61 ± 0.53 million/ul respectively, the percentage of change was 0.04%. There was statistical significant increase in RBCs post-study in group B (p = 0.050) (Table 3).

Between groups comparison: There was no statistical significant difference in the mean values of RBCs between both groups pre-study and post-study (p= 0.148 and 0.206 respectively) (Table 3).

3- Hematocrit: Within group comparison, the mean value of HCT pre- and post-study of group A was 41.7 ± 3.4 and 41.5 ± 3.7 % respectively; the percentage of change was 0.17%. There was no statistical significant difference between pre- and post-study in HCT in group A (p = 0.384). The mean value of HCT pre- and post-study of group B was 42.87 ± 3.49 % and 43.32 ± 3.56 % respectively; the percentage of change was 0.45%. There was statistical significant increase in HCT post-study in group B (p = 0.006) (Table 3).

Between groups comparison, there was no statistical significant difference in the mean values of HCT between both groups pre-study (p= 0.135). There was statistical significant increase in HCT post-study in group B than in group A (p=0.031) (Table 3).

4- Platelets: Within group comparison, the mean value of platelets pre- and post-study of group A was 285.27 ± 84.76 and 287.37 ±81.87 (103/ul) respectively; the percentage of change was 2.1%. There was no statistical significant difference between pre- and post-study in platelets in group A (p = 0.742). The mean value of platelets pre- and post- study of group B was 248.15 ± 50.81 and 254.52 ± 50.60 (10^3/ul) respectively; the percentage of change was 6.37 %. There was statistical significant increase in platelets post-study in group B (p = 0.014) (Table 3).

Between groups comparison, There was statistical significant decrease in the mean values of platelets pre-study and post-study in group B than in group A (p= 0.02 and 0.034) (Table 3).

5- White blood cells: Within group comparison, the mean value of WBCs pre- and post-study of group A was 6.73 ± 2.1 and 6.77 ± 2.2 (10^3/ul) respectively; the percentage of change was 0.04%. There was no statistical significant difference between pre- and post-study in WBCs in group A (p = 0.779). The mean value of WBCs pre- and post-study of group B was 6.51 ± 1.5 and 6.66 ± 1.54 (103/ul) respectively; the percentage of change was 0.15%. There was statistical significant increase in WBCs post-study in group B (p = 0.03) (Table 3).

Between groups comparison, there was no statistical significant difference in the mean values of WBCs between both groups pre-study and post-study (p= 0.802 and 0.954) (Table 3).

6- Neutrophils: Within group comparison, the mean value of neutrophils pre- and post-study of group A was 3.36 ± 1.4 and 3.5 ± 1.6 (10^3/ul) respectively; the percentage of change was 0.15 %. There was no statistical significant difference between pre- and post-study in neutrophils in group A (p = 0.168). The mean value of neutrophils pre- and post-study of group B was 3.35 ± 1.18 and 3.48 ± 1.19 (10^3/ul) respectively; the percentage of change was 0.12 %. There was statistical significant increase in neutrophils post study in group B (p = 0.005) (Table 3).

Between groups comparison, there was no statistical significant difference in the mean values of neutrophils between both groups pre-study and post-study (p= 0.868 and 0.817) (Table 3).

Effect of acute aerobic exercise on O_2 saturation: Within group comparison, the mean value of O_2 saturation pre- and post-study of group A was 96.85 ± 2.91 and 97.1 ± 1.44% respectively; the percentage of change was 0.25%. There was no statistically significant difference between pre- and post-study in O_2 saturation in group A (p = 0.567). The mean value of O_2 saturation pre- and post-study of group B was 96.87 ± 3.33 and 96.37 ± 2.96 % respectively; the percentage of change was 0.5%. There was statistical significant decrease in O_2 saturation post study in group B (p = 0.033) (Table 3).

Between groups comparison, there was no statistical significant difference in the mean values of O_2 saturation between both groups pre- study and post-study (p= 0.972 and 0.169) (Table 3).

Table (3): Descriptive statistics and 2×2 mixed MANOVA design for measured variables

Hematological parameters	Group A Mean ±SD	Group B Mean ±SD	F-value	P-value	η2
Hb (g/dl)					
Pre-study	14.26 ±1.06	14.61 ±1.10	1.650	0.203	0.021
Post study	14.28 ± 1.1	14.68 ±1.06	3.863	0.053	0.047
% of change	0.02%	0.07%			
P-value (within group)	0.516	0.015*			
RBCs (million/ul)					
Pre-treatment	5.386 ±0.474	5.56 ±0.51	2.137	0.148	0.027
Post treatment	5.388 ± 0.473	5.61±0.53	1.626	0.206	0.02
% of change	0.002%	0.04%			
P-value (within group)	0.933	0.050*			
HCT (%)					
Pre-treatment	41.7 ± 3.4	42.87 ±3.49	2.280	0.135	0.028
Post treatment	41.5 ± 3.7	43.32 ±3.56	3.65	0.031**	0.058
% of change	0.17 %	0.45%			
P-value (within group)	0.384	0.006*			
Platelet (103/ul)					
Pre-treatment	285.27 ±8.76	248.15 ±50.81	5.645	0.02**	0.067
Post treatment	287.37 ±8.87	254.52 ±50.60	4.659	0.034**	0.056
% of change	2.1 %	6.37 %			
P-value (within group)	0.742	0.014*			
WBCs (103/ul)					
Pre-treatment	6.73 ± 1.1	6.51 ±1.55	0.063	0.802	0.001
Post treatment	6.77 ± 1.2	6.66 ±1.54	0.003	0.954	0.001
% of change	0.04%	0.15 %			
P-value (within group)	0.779	0.03*			
Neutrophils (103/ul)					
Pre-treatment	3.36 ± 0.4	3.35 ±0.18	0.028	0.868	0.001
Post treatment	3.5 ± 0.6	3.48 ±0.19	0.054	0.817	0.001
% of change	0.15 %	0.12 %			
P-value (within group)	0.168	0.005*			
O2 saturation (%)					
Pre-treatment	96.85±2.91	96.87 ±3.33	0.001	0.972	0.001
Post treatment	97.1±1.44	96.37 ±2.96	1.929	0.169	0.024
% of change	0.25%	0.5%			
P-value (within group)	0.567	0.033*			

*Significant t test as P value ≤ 0.05, *: P value within group comparison, **: P value between groups comparison, SD: standard deviation, Hb: Hemoglobin, η2: partial eta square.

DISCUSSION

Opioid dependence, particularly in individuals withdrawing from heroin, significantly affects various hematological parameters, suggesting a suppressed immune response and altered blood components. This aligns with studies of **Quraishi** [4] and **Shahabinejad *et al.*** [8] who reported that opioid addiction disrupts the immune system and increases the risk of cardiovascular conditions. Opioid use, especially heroin, also contributes to respiratory problems, including low oxygen saturation and decreased respiratory rate [9].

In contrast, physical activity has been shown to induce beneficial changes in hematological parameters, including leukocytes, red blood cells (RBCs), and platelets, especially in response to moderate-to-high intensity exercise [10, 11]. Aerobic exercise, in particular, has demonstrated therapeutic benefits for individuals in addiction recovery, improving abstinence rates and reducing withdrawal symptoms [7]. However, excessive physical exertion can paradoxically increase the generation of reactive oxygen species, suggesting a need for balanced exercise programs in addiction rehabilitation [12]. Based to our information, this is the first study that aimed to investigate changes in selective hematological parameters and oxygen saturation in heroin withdrawal addicts following acute aerobic exercise, providing insights for future studies related to heroin addiction recovery.

Hemoglobin and hematocrit, pre-exercise comparisons: The study revealed no significant differences in hemoglobin (Hb) and hematocrit (Hct) levels between the heroin withdrawal group (Group A) and the non-addict control group (Group B). This finding is consistent with previous studies by **Verde Méndez *et al.*** [13] who found similar Hb and Hct levels in control groups and opiate addicts. Chronic heroin use likely leads to adaptations that maintain erythropoiesis and oxygen delivery, despite disruptions in other aspects of blood composition.

Effects of Acute Exercise on Hb and Hct in Non-Addicts: Group B (non-addicts) showed significant increases in Hb and Hct following 30 minutes of moderate-intensity aerobic exercise ($p = 0.015$ for Hb and $p = 0.006$ for Hct). This supports findings from studies of **Noushad *et al.*** [14] and **Erdoğdu *et al.*** [15] where moderate-intensity aerobic exercise caused increases in RBCs count, Hb, and Hct due to exercise-induced hematopoietic responses and enhanced oxygen transport.

Hematological changes in competition-like scenarios: Previous studies by **Koc *et al.*** [11] and **Shapoorabadi *et al.*** [16] suggests that high-intensity or competition-like exercises result in more significant increases in Hb and Hct, optimizing oxygen delivery during intense physical exertion.

Mixed findings in long-term aerobic programs: While, some studies show that long-term aerobic training leads to minimal changes in Hb and Hct [17], others show that short-term acute exercise leads to transient increases in hematological parameters [18]. These mixed results may be explained by variations in exercise intensity, duration, and individual factors.

Mechanisms Underlying Acute Hematological Changes: The increase in Hb and Hct after exercise is likely driven by factors such as spleen contraction and fluid shifts. Sympathetic nervous system activation causes the release of RBCs from storage sites, and fluid shift lead to hemoconcentration, temporarily raising hematological values [18, 19].

For heroin addicts, the lack of significant changes in Hb and Hct after exercise could be due to physiological adaptations from chronic drug use, comorbidities such as respiratory impairments, or insufficient exercise intensity or duration to trigger a measurable hematological response.

Red blood cells (RBCs): Pre-exercise comparisons were similar to the findings for Hb and Hct where RBCs counts in group A (heroin withdrawal addicts) showed no significant differences compared to group B (non-addicts) before exercise ($p = 0.148$). This is consistent with findings of **Verde Méndez *et al.*** [13]**.** Chronic heroin use and withdrawal do not appear to significantly alter RBCs counts but may affect other aspects of erythropoiesis and blood composition.

Effects of exercise on RBC counts: Post-exercise, group B showed a significant increase in RBCs count ($p = 0.050$), which is consistent with findings of **Erdoğdu *et al.*** [15] where exercise increased RBC counts and Hb. In contrast, group A exhibited a minimal, statistically insignificant change in RBC levels ($p = 0.933$), suggesting that heroin withdrawal may impair the typical hematological response to exercise.

Several factors may explain this lack of response in group A:

Chronic opioid use and hematological alterations: Heroin use may disrupt erythropoiesis, leading to altered RBC production and reduced responsiveness to exercise [2].

Nutritional deficiencies: Heroin addiction is associated with nutritional deficiencies that further impair erythropoiesis and limit the body's ability to respond to exercise-induced hematological changes [20].

Platelets

Platelet analysis: Group A showed no significant change in platelet counts post-exercise ($p = 0.742$). While, the mean platelet count increased slightly (2.1%), this was not statistically significant, possibly due to the regulation of platelet homeostasis and the short duration/intensity of the exercise intervention. Additionally, medications used to manage withdrawal symptoms may stabilize platelet levels and mask exercise-induced changes. In contrast, group B exhibited a significant increase in platelet count post-exercise (p = 0.014), which is consistent with studies of **Rekha & Hyderabad** [21] and **Okeke Chizoba *et al.*** [10]**,** which showed exercise-induced increases in platelet count.

Mechanisms behind platelet increase: Platelets may increase due to mobilization from storage sites (e.g., the spleen) and exercise-induced spleen contraction [22]. Hemoconcentration during exercise may also lead to a temporary increase in platelet counts [18].

White blood cells (WBCs):

WBC changes: Within group A, WBC counts did not show significant changes after exercise (p = 0.779). This suggests that heroin withdrawal may blunt the typical immune response to exercise, possibly due to impaired immune function in withdrawal addicts. Group B, however, showed a significant increase in WBC count post-exercise (p = 0.03), which is consistent with **Azarbayjani *et al.*** [18] and **Peake *et al.*** [23] who highlighted the immune-enhancing effects of exercise.

Mechanisms behind WBC increase: Exercise stimulates the release of WBCs from storage sites such as the spleen and bone marrow [24]. Cortisol release during exercise further promotes the mobilization of leukocytes into circulation [25].

Neutrophils

In group A (Heroin Withdrawal Addicts), the neutrophil count slightly increased from 3.36 ± 1.4 to 3.5 ± 1.6 ($10^3/\mu L$), but this change was not statistically significant (p = 0.168). The increase in neutrophils was minimal and remained within the normal range. Potential reasons for this stability include the absence of factors like infections or medications affecting neutrophils, individual variability in baseline counts, and the moderate intensity of the exercise not being sufficient to induce a significant immune response. In contrast, group B (Healthy Individuals) showed a significant increase in neutrophil count (p = 0.005), supporting the role of acute exercise in enhancing immune function. Previous studies by **Benoni *et al.*** [5] and **Brown *et al.*** [26] confirmed that exercise mobilizes neutrophils through mechanisms like catecholamine and cortisol release, and shear stress induced by exercise. This neutrophil response is typically transient, returning to baseline within 3-6 hours post-exercise [11, 19]. Comparative analysis between the two groups showed no significant difference in neutrophil counts (p = 0.868 and p = 0.817 respectively), suggesting that while exercise had a measurable effect in healthy individuals, the overall neutrophil response was similar between heroin addicts and healthy participants. This aligns with **Haghpanah *et al.*** [3]**.**

Oxygen saturation: Group A showed no significant change in oxygen saturation, with pre- and post-exercise levels remaining stable (p = 0.567). This could be attributed to long-term heroin use altering respiratory function, lowering baseline fitness levels, or pre-existing respiratory conditions. On the other hand, group B experienced a statistically significant decrease in oxygen saturation post-exercise (p = 0.033). This aligns with previous studies that reported a transient decline in oxygen saturation following aerobic exercise, especially in less-fit individuals [27, 28]. There were no significant differences in oxygen saturation between the two groups (p = 0.972 and p = 0.169), suggesting that baseline fitness and health did not substantially differ, and the moderate exercise intensity may not have been enough to reveal distinct physiological responses between the groups.

CONCLUSION

The findings of this study highlighted the differential effects of acute aerobic exercise on hematological parameters and oxygen saturation in heroin withdrawal addicts (Group A) compared to healthy individuals (Group B). While group B demonstrated significant adaptive responses, group A exhibited limited changes, likely due to the physiological disruptions associated with chronic opioid addiction. These results emphasize the need for tailored exercise interventions to enhance recovery for individuals in heroin withdrawal. Furthermore, these findings provide valuable insights for future research, aimed at optimizing rehabilitation strategies and addressing the specific challenges faced by heroin addiction recovery patients.

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