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Original Research Article

In Sedentary Post-Pubertal Boys and Girls, High-Intensity Exercise Alters the Hematological Profile: A Comparative Study

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Abstract

Background: In addition to damaging red blood cells (RBCs) and causing hemolysis due to osmotic and mechanical stress, high-intensity exercise also promotes intensity-dependent leukocytosis as a result of enhanced white blood cell trafficking in circulation. The purpose of this research was to look into how post-pubertal boys and girls who were inactive could have their hematological profiles altered by high-intensity exercise.

Method: Twenty sedentary post-pubertal boys and twenty sedentary girls had blood drawn before and right after exercise to measure hematological parameters like RBC count, hematocrit, and hemoglobin concentration (Hb), total leukocyte counts, and differential count.

Results: RBC count, hemoglobin, and hematocrit did not differ significantly across groups before and after exercise. In post-pubertal males, hematocrit and hemoglobin levels were considerably greater before and after exercise (P <0.002). Before the exercise, there was no significant intergroup variance in the leukocyte count, however, both groups' post-exercise counts increased significantly (P 0.002). Post-pubertal boys had considerably (P <0.02) greater monocities and neutrophilia. While there was no discernible intergroup variation in the percentage change of monocytes, eosinophils, or basophils, the percentage rise in neutrophils was considerably (P <0.02) larger in boys than in girls. Girls had considerably (P <0.002) greater absolute lymphocyte counts and percentage increases following exercise compared to boys. Although the relative eosinophil count dramatically decreased in both groups, the absolute eosinophil count greatly increased, perhaps as a result of the faster rate of lymphocyte and neutrophil mobilization. In the aftermath of exercise, the basophil count was similarly disturbed.

Conclusion: Except for the presence of neutrophils and lymphocytes, gender did not seem to significantly affect the exercise-induced disturbance in the hematological profile at the post-pubertal stage.

Keywords: Hematocrit, Gender, Total and Differential Counts, and Total Count.

Introduction

Due to increased blood cell trafficking into circulation, acute high-intensity exercise increased white blood cell (WBC) count [1,2]. According to studies, the intensity, length, and level of personal fitness all affect how much the leukocyte count is perturbed. Frequent moderate exercise has been shown to improve immunological function, however overtraining or high-intensity exercise may have negative effects on the immune system [3]. Some reports showed no discernible impact of exercise [7].

Increased total leukocyte counts, particularly neutrophil counts, are frequently utilised to signify an inflammatory response linked to exercise-induced heart stress and skeletal muscle injury [8; Figure 1]. Moreover, studies have shown that exercise-induced basophil and eosinophil trafficking may play a significant role in exercise-induced bronchoconstriction, allergy symptoms, and hyperresponsiveness of the upper respiratory tract [9,10]. Likewise, it has been documented that exercise causes red blood cell (RBC) damage and hemolysis due to osmotic and mechanical stress brought on by exercise [11; Figure 2], foot stroke hemolysis [12,13], and free radical-mediated lipid peroxidation of RBC membrane [14,15].

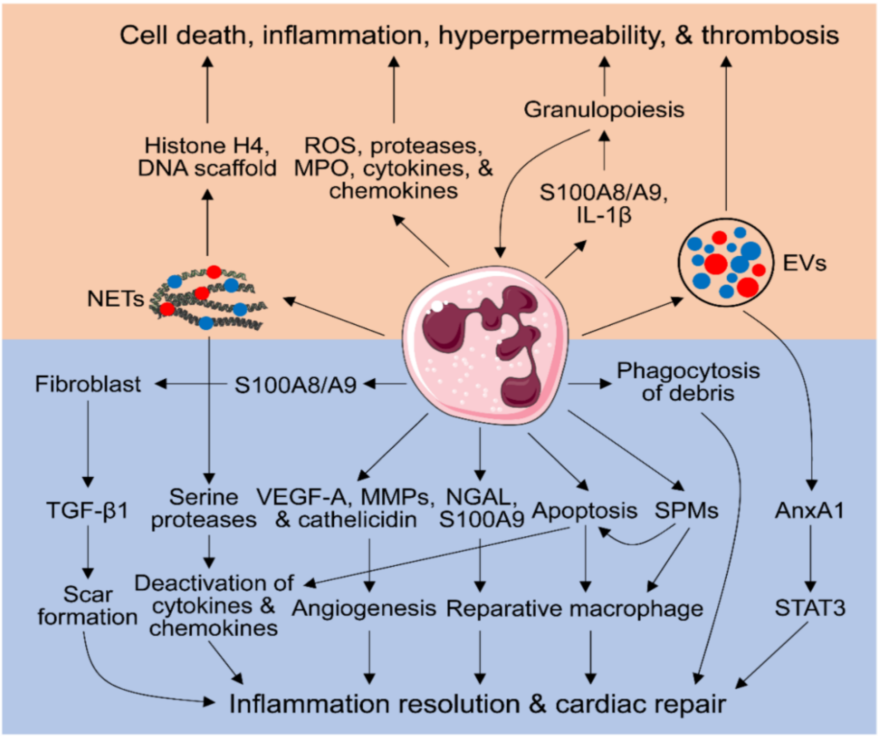

Figure 1: Neutrophil Function in Myocardial Infarction-Related Heart Damage and Repair

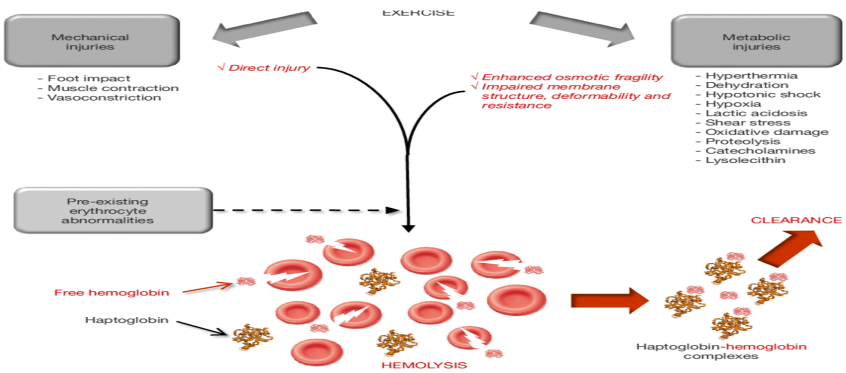

Figure 2: Exercise induces osmotic and mechanical stress, which leads to hemolysis and red blood cell (RBC) destruction.

The total leukocyte counts significantly increased after exercise in several investigations with adult male volunteers, primarily due to an increase in neutrophil and lymphocyte counts [16,17]. However, one of the most recent studies done on trained adult female soccer players found that after one session of vigorous activity at 75% of maximal heart rate, neutrophilia but not lymphocytosis was reported [18]. These investigations suggested that the hematological changes brought on by exercise may differ depending on the gender. Research into how gender affects exercise-induced changes in blood cell count have not been sufficiently studied, particularly in adolescent sedentary subjects.

In adult male and female subjects (aged 19–44 years, with an average age of 23 years), Sand et al. [19] investigated the gender impact on exercise-induced perturbations in response to two different types of exercise, namely running and cycling, and found no gender differences in the pattern of neutrophilia, lymphocytosis, or monocities after exercise [19]. Research examining the effects of gender on exercise-induced variations in blood cell count in adolescents are incredibly rare. In the post-pubertal population, particularly the sedentary ones, the pattern of gender variance in post-exercise hematological alterations has not been thoroughly studied.

The objective of the present research was to compare baseline hematological parameters between boys and girls who were sedentary after puberty, looking for gender differences as well as changes brought on by high-intensity incremental running exercise in terms of total RBC count, WBC count, hematocrit, hemoglobin (Hb) concentration, absolute and relative counts of lymphocyte, monocyte, neutrophil, eosinophil, and basophil.

Method:

For the current study, 20 sedentary school-going post-pubertal boys and 20 girls were randomly selected. According to Tremblay et al. [20] and the World Health Organization [21], children between the ages of 5 and 17 are considered to be sedentary if they spend more than two hours per day engaging in sedentary activities or watching leisurely television, and if they get no more than 60 minutes of moderate physical activity per day. The subjects who were chosen for the study were sedentary for almost 8–9 hours without engaging in any significant physical exercise. They did not participate in any physical training or conditioning regimen. Study participants who had a history of serious illnesses or were taking medication were not allowed to participate.

The female study participants did not utilize any form of birth control. Tanner's staging criterion was used to determine whether male and female individuals had reached puberty [22]. All of the female subjects had regular menstrual cycles, and the female subjects' reproductive cycles were closely observed throughout the study. Women who participated in the exercise routine did so between 10 and 13 days after the start of their menstrual cycle. They most likely had the highest level of estradiol circulating during this time [23].

Three weeks before to the experimental trials, the volunteers did not exercise in any way. All subjects received a standard, balanced diet starting one month before to the experiment, in accordance with recommendations made by the National Institute of Nutrition, I.C.M.R. [24] The study was carried out at the Nalanda Medical College and Hospital, Patna from July 2021 to December 2022.

The data was statistically analyzed using the Statistical Package for the Social Sciences. The data are displayed as mean SE. To find a significant difference between the mean values of hematological parameters assessed before and after the exercise, paired t-tests were carried out independently in each group. The independent sample t-test was used to identify any significant differences in the parameters' mean values between the two groups as well as significant intergroup differences in the parameters' mean values for percentage change after exercise. The significance threshold was established at P <0.04.

Results

The patients' physical attributes, body mass index (BMI), pre-exercise heart rate, blood pressure, running time to exhaustion, and distance travelled during the exercise trial are shown in [Table 1]. The respondents' BMI values were within the normal range, with boys having a considerably (P <0.04) greater value than girls. In addition, boys had considerably higher body height and mass (P< 0.002) than girls. Girls had considerably (P< 0.002) greater resting heart rates. Blood pressure, the average amount of time spent running till fatigue, and the average distance travelled while using a treadmill did not differ across groups [Table 1].

Table 1: The participants' physical and physiological attributes, as well as their running distance and time to exhaustion.

Group	Body height (cm)	Body mass (kg)	Body mass index (kg m^{-2})	Pre-exercise heart rate (beats. Min^{-1})	Blood pressure (mm of Hg)		Mean running time (min)	Average distance covered during trial
					Systolic	Diastolic		
Boys (n=20)	158.31 ±0.85	49.91 ±0.56	19.96 ±0.56	70.4 ±0.90	110.76 ±0.83	71.44±0.41	50.6 ±1.6	7.50 ±0.41
Girls (n=20)	153.90 ±0.70	44.75 ±0.51	18.91 ±0.18	76.08 ±0.85	112.35 ±1.36	69.26 ±1.08	47.45 ±2.28	6.46 ±0.37

The values for the hematological parameters before and after exercise, as well as the percentage change, are shown in [Table 2]. Boys who were post-pubertal had significantly greater pre- and post-exercise hematocrit and Hb concentration (P< 0.002).

Table 2: Hematological markers that change after exercise

Variable	Group	Absolute Count		Percentage Change
		Before Exercise	After Exercise	
Red blood cell (X 10^{12}/L)	Girls	4.82±0.06	4.84±0.05	0.40±0.41
	Boys	4.96±0.07	5.01±0.07	0.78±0.51
White blood cell (/CUMM	Girls	9195±316	10425±355	29.13±4.24
	Boys	36.42±0.31	10071±300	22.26±1.02
Hematocrit	Girls	40.03±0.31	36.81±0.54	1.31±1.97
	Boys	40.03±0.51	40.04±0.51	0.05±0.48
Hemoglobin (g/dl)	Girls	12.13±0.11	12.26±0.17	1.31±1.97
	Boys	13.34±0.15	13.33±0.16	-0.008±0.51

RBC counts before and after exercise did not substantially differ between the groups. Following exercise, RBC count, Hb, and hematocrit did not vary considerably either, and there was no inter-group difference in the percentage change for these variables. Following exercise, the absolute leukocyte counts significantly rose in both groups (P<0.002). The size of the percentage change in leukocyte count after activity and the difference between pre- and post-exercise values, however, were not significantly different across the groups.

The presentation in includes the relative as well as absolute count of leukocyte subtypes. Boys' absolute monocyte counts were considerably greater before exercise (P = 0.02), but girls' absolute lymphocyte counts were significantly higher at rest (P = 0.04). Absolute neutrophil, eosinophil, and basophil baseline values did not significantly differ across groups.

Following the exercise experiment, the boys' group experienced a significant rise in the absolute counts of lymphocytes, monocytes, neutrophils, eosinophils, and basophils (P <0.002). Moreover, there was a substantial rise in the absolute lymphocyte (P< 0.001), neutrophil (P<0.01), eosinophil (P <0.03), and basophil (P <0.01) counts in females in response to exercise. 4Girls considerably outperformed boys in terms of post-exercise absolute lymphocyte count as well as percentage increase (P <0.04). Despite the fact that boys had significantly greater post-exercise absolute monocyte counts (P <0.02), intergroup variation in monocyte percentage change did not reflect intergroup variation. When compared to girls, boys had significantly higher post-exercise absolute neutrophil counts (P < 0.012) and percentage increases (P <0.002). There was no discernible difference between the groups in terms of the percentage change in absolute eosinophil and basophil count.

Girls' baseline relative lymphocyte counts were considerably higher than boys' (P <0.002), but boys' pre-exercise relative neutrophil and monocyte counts were significantly higher than girls' (P <0.4) and women's (P <0.02). Both boys and girls saw a substantial increase in the relative number of lymphocytes (P< 0.002), with the post-exercise value (P <0.002) and percentage increase (P <0.04) being larger in females. Yet, following exercise, relative neutrophil count considerably decreased (P< 0.02) in females while significantly increasing (P <0.002) in boys. Boys experienced a considerably larger relative neutrophil count increase (P <0.002). After exercise, the relative proportion of monocytes in both groups fell significantly (P< 0.002). In contrast, there were no discernible intergroup differences in post-exercise value or percentage change in relative monocyte count. Boys, but not girls, experienced a substantial decline in relative eosinophil count (P <0.002). In comparison to females, boys experienced a substantially larger percentage change in the relative eosinophil count (P < 0.02). Exercise had no effect on either the post-exercise value or the % change in the relative basophil count.

Discussion

Exercise causes a temporary change in blood cell count, particularly in lymphocytes and neutrophils, which is a reflection of the immune system's altered immunological function brought on by stress and the inflammatory reaction to exercise. The current study looked at how gender affected the changes in blood cell count and hematological parameters brought on by exercise in sedentary boys and girls after subjecting them to high intensity progressive treadmill running.

According to the current study, post-pubertal boys had higher basal hemoglobin and hematocrit levels than girls their age. In contrast, there was no discernible gender difference in the RBC and WBC count baseline values.

RBC count, Hb, and hematocrit levels were not significantly altered by acute high-intensity exercise stress in either group, and there was no discernible gender difference in the pattern of changes in these parameters after exercise. Exercise causes osmotic and mechanical stress, foot stroke hemolysis, [12,13] free radical-mediated lipid peroxidation of the RBC membrane, and RBC damage and hemolysis, according to earlier reports [14,15]. Such intravascular hemolysis brought on by exercise raises plasma Hb content after the exercise [25]. However, it is clear from the current study that acute high-intensity concentric incremental running exercise of shorter duration did not cause any significant change in RBC count or Hb among sedentary post-pubertal population, suggesting that such exercise stress might not induce significant erythrocyte damage due to mechanical and osmotic stress or due to free-radical mediated damage. Although acute high-intensity exercise of less time did not affect erythrocyte count and Hb significantly, more research is needed to determine how long duration endurance exercise affects these variables.

Contrary to erythrocyte count, both groups' total absolute leukocyte counts considerably rose. Research demonstrated that both groups experienced excessive leukocytosis following exercise stress. Exercise of a high intensity has been demonstrated to cause leukocytosis, the degree of which depends on the duration and intensity of the activity [1,2,4]. Such exercise-induced leukocytosis, according to studies, was mostly brought on by the release of lymphocytes, monocytes, and neutrophils into the bloodstream in response to exercise stress [2,5,26]. The release of catecholamines like epinephrine and norepinephrine during high-intensity exercise increases sympathetic activity, which in turn causes an increase in the total leukocyte count by promoting the movement of immune cells like lymphocytes from lymphoid organs like the spleen into circulation [27–29]. On the other hand, in reaction to exercise, neutrophils are mostly recruited from the bone marrow and other marginated pools like the lungs into the peripheral circulation, causing profuse leukocytosis [30]. Although females had a slightly higher post-exercise value and % rise in total leukocytes, this intergroup difference was determined to be statistically insignificant, suggesting that gender may not affect exercise-induced changes in total leukocyte count in this age group.

WBC sub-type analysis revealed that the absolute and relative baseline lymphocyte counts in girls were considerably higher than those in boys, indicating that the proportion of lymphocytes in circulation may be larger in teenage girls than in age-matched boys. However, post-pubertal girls had considerably higher post-exercise values and a larger absolute lymphocyte count rise as determined by this parameter's percentage increase. In response to exercise, post-pubertal girls reported a 51.90% rise in circulating lymphocytes, compared to a 31.94% increase in lymphocyte count observed in boys. Research demonstrated that increases in blood lymphocyte count brought on by exercise are more likely to occur in girls.

Moreover, girls had a considerably greater post-exercise percentage rise in the relative proportion of lymphocytes in circulation. Results indicated that females' relative lymphocyte proportion in total leukocyte count remained significantly greater both before and after exercise, in addition to the extent of post-exercise lymphocyte trafficking.

Boys had considerably higher absolute and relative monocyte counts at rest and after exercise, indicating that boys always had a higher proportion of this leukocyte subtype regardless of exercise stress. Boys who underwent exercise stress experienced a considerable rise in their absolute monocyte count, but not girls. However, no gender-specific differences in the pattern of monocities were seen, as evidenced by the almost identical % change in absolute monocyte count after exercise.

Following exercise, relative monocyte counts actually fell in both groups. Although girls saw a slightly faster rate of drop in the relative proportion of monocytes in circulation after exercise, this gender difference was not statistically significant. This decrease in relative monocyte count was likely caused by relatively more exercise-induced lymphocyte trafficking, which decreased the relative proportion of monocytes to the overall amount of WBC in circulation.

Significant increases in post-exercise absolute neutrophil count show that exercise significantly increased neutrophilia in both groups after the exercise session. Similar immediate neutrophilia in response to acute exercise was corroborated by earlier studies [2]. The earlier studies also suggested that exercise-induced mobilization of neutrophils into the peripheral circulation, primarily from the bone marrow and other marginated pools like the lungs, results in profuse neutrophilia [30].

The amount of neutrophil mobilization into circulation in response to exercise stress was also clearly greater in boys, as seen by their higher post-exercise value and relative absolute neutrophil count rise. Previous research suggested that the increase in neutrophil count after exercise might be an inflammatory reaction to exercise-induced muscle injury, wherein neutrophils are drawn to the injured muscle fibers to clear out the dead tissues [31]. Previous research has shown that men are more prone than women to sustain greater skeletal muscle injury as a result of exercise [32]. Also, it has been proposed that the subjects' muscle mass influences how much neutrophils are recruited after exercise. Timmons et al. [2] previously suggested that in healthy children and adolescents, the degree of post-exercise neutrophilia may be significantly linked with fat free mass [2].

As a result, the post-exercise increase in neutrophil count will be greater the more muscle mass the subjects had. In the current study, boys' BMI was noticeably greater than girls. Boys' greater muscular mass may have also contributed to their stronger neutrophil recruitment during exercise. Boys' bigger muscle mass and greater degree of exercise-induced skeletal muscle injury and inflammation may therefore be responsible for the observed gender difference in their stronger post-exercise neutrophil response. Additionally, it has been suggested that the post-exercise neutrophilia may directly be related to the exercise-induced increase in cortisol level, and that people with greater post-exercise cortisol levels are likely to have higher exercise-induced neutrophilia. [2,26] Interleukin-6 (IL-6) may be yet another potential mediator of exercise-induced neutrophil migration into circulation, and exercise-induced release of IL-6 from working muscle may also be to blame for higher cortisol secretion during acute high-intensity exercise, according to research [33]. Previous research also revealed a statistical relationship between post-exercise IL-6 levels and neutrophil counts [30,31].

Boys exhibited a considerably greater relative proportion of neutrophils both before and after exercise, according to analysis of relative neutrophil count. Girls' relative neutrophil counts drastically dropped after exercise. [33]

The relative neutrophil count in boys, on the other hand, significantly increased. The relative neutrophil count changed differently depending on gender, and boys experienced a noticeably bigger percentage increase in this measure. Girls' relative neutrophil proportion in total leukocyte decreased after exercise, probably due to a relative faster rate of lymphocyte mobilization (lymphocytosis) during exercise compared to neutrophil release (neutrophilia). This factor may have been responsible for the girl's substantial increase in absolute count despite a significant fall in the relative fraction of neutrophils in the total leukocyte count after exercise. [34]

Although the absolute eosinophil count increased significantly in both groups, there were no gender differences in the trafficking of eosinophil caused by exercise, as demonstrated by the identical post-exercise increases in both groups. Nonetheless, a key discovery is that both groups' relative eosinophil proportions decreased dramatically, with boys experiencing a greater decline than girls.

There was a decline in the relative proportion of these parameters in the total WBC count because the relative rate of rise in lymphocyte and neutrophil count was substantially larger in both groups than the exercise-induced trafficking of eosinophil into circulation.

Although considerable increases in absolute basophil count in both groups, no discernible gender difference in either the absolute or relative count of this variable could be seen. Strenuous exercise has been linked to an increased risk of upper respiratory tract infections, hyperresponsiveness, and bronchoconstriction brought on by airway mucosal inflammation, according to numerous earlier research [9]. The increase in eosinophils after exercise may have significant effects on exercise-induced reactions in the upper respiratory tract because eosinophils have been identified as one of the pro-inflammatory cells responsible for upper respiratory tract reactions, including damage to the respiratory epithelium [9]. Moreover, it has been proposed that exercise may result in hypoxemia due to an increase in histamine levels, which are mostly generated by basophils [10]. Eosinophil and basophil levels rose similarly in both groups in our investigation, suggesting that the risk of post-exercise upper respiratory tract hyperresponsiveness and hypoxemia is likely to be similar in both groups regardless of gender and physiological differences between the groups.

Conclusion

In post-pubertal boys and girls, high-intensity progressive treadmill running did not result in any appreciable changes to RBC count, Hb, or hematocrit. In sedentary adolescent subjects, the degree of post-exercise fluctuation in such indicators may not be altered by gender. Exercise-induced lymphocytosis and neutrophilia were primarily responsible for the significant leukocyte count disturbance in both groups. Gender had a large impact on the amount of lymphocyte and neutrophil trafficking following exercise. The rate of exercise-induced neutrophil trafficking was significantly higher in males, whereas the post-exercise disturbance in lymphocyte count was significantly larger in girls. Boys' bigger muscle mass and more vulnerability to exercise-induced muscle injury may be the cause of their higher post-exercise neutrophil mobilization. Girls' relative neutrophil counts were significantly reduced as a result of the post-exercise trafficking of lymphocytes, which was relative higher in girls. Only among the boys was significant exercise-induced monocities seen.

However, there was no discernible difference between the sexes in the degree of monocyte mobilization following exercise. Although both groups' absolute eosinophil counts dramatically increased, boys' relative counts significantly decreased due to a faster rate of lymphocyte and neutrophil mobilization. Gender didn't seem to have much of an effect on the basophil count change brought on by exercise.

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