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High intensity exercise induced alteration of hematological profile in sedentary post-pubertal boys and girls: A comparative study

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ABSTRACT

Objectives: High-intensity exercise induces intensity dependent leukocytosis due to increased trafficking of white blood cells in circulation and also causes red blood cell (RBC) damage and hemolysis due to osmotic and mechanical stress. The present study was aimed to investigate the high-intensity exercise-induced perturbations of hematological profile in sedentary post-pubertal boys and girls.

Materials and Methods: Blood samples were collected from sedentary post-pubertal boys (n = 22, age = 16.10 ± 0.74 years) and girls (n = 22, age = 16.04 ± 0.63 years) before and immediately after exercise to assess hematological parameters such as RBC Count, hematocrit, hemoglobin concentration (Hb), total leukocyte counts, and differential count.

Results: Pre- and post-exercise RBC count, Hb and hematocrit had no significant inter-group variation. Pre- and post-exercise hematocrit and Hb were significantly ($P < 0.001$) higher in post-pubertal boys. Leukocyte count had insignificant intergroup variation before the exercise but it increased significantly ($P < 0.001$) following exercise in both the groups. Monocytosis and neutrophilia were significantly ($P < 0.01$) higher in post-pubertal boys. Percentage change in monocyte, eosinophil and basophil did not depict significant inter-group variation while percentage increase in neutrophil was significantly ($P < 0.01$) higher in boys as compared to girls. Post-exercise absolute lymphocyte count as well as percentage increase in this variable was significantly ($P < 0.001$) higher in girls as compared to boys. Absolute eosinophil count increased significantly in both the groups but its relative count declined substantially probably due to higher rate of mobilization of lymphocyte and neutrophil. Basophil count was also perturbed following exercise.

Conclusion: Gender appeared to have insignificant impact on exercise-induced perturbation in hematological profile at post-pubertal stage except for neutrophil and lymphocyte.

Keywords: Total count, Differential count, Hematocrit, Gender.

INTRODUCTION

Acute high-intensity exercise increased white blood cell (WBC) count due to increased trafficking of blood cells into circulation.[1,2] Studies revealed that the extent of perturbation in leukocyte count depends on intensity, duration and level of individual fitness. Regular moderate exercise is known to boost immune function while high-intensity exercise or overtraining may result in adverse changes in immune system.[3] Other reports depicted no significant influence of exercise trial on leukocyte subset counts.[1,4-6] High-intensity exercise led to significant leukocytosis mediated mostly by transitory lymphocytosis and monocytosis, followed by a delayed neutrophilia in young adults.[4] Such sustained neutrophilia may persist up to 1–5 h following exercise.[7] This increased total leukocyte counts especially neutrophil count is widely used to indicate inflammatory response associated with exercise-induced skeletal muscle damage and cardiac stress.[8] Research also indicated that exercise-induced trafficking of basophil and eosinophil may have important role in exercise-induced upper respiratory tract hyper-responsiveness, bronchoconstriction, and allergic manifestations.[9,10] Similarly, it was also reported that exercise leads to red blood cell (RBC) damage and hemolysis on account of osmotic and mechanical stress induced by exercise,[11] foot stroke hemolysis[12,13] and free-radical mediated lipid peroxidation of RBC membrane.[14,15]

Several studies conducted in adult male subjects reported significant post-exercise increase in total leukocyte count mostly on account of increase in neutrophil and lymphocyte count.[16,17] However, one of the recent studies conducted in trained adult female soccer players reported only neutrophilia but not lymphocytosis after one bout of intense exercise at 75% of maximal heart rate.[18] These studies indicated that there might be gender based variation in hematological alteration in response to exercise. Studies investigating impact of gender on exercise-induced perturbations in blood cell count has not been adequately investigated, especially among adolescent sedentary subjects. Sand *et al.*[19] examined the gender impact on exercise-induced perturbations in adult male and female subjects (age 19–44 years and average 23 years) in response to two different forms of exercise, namely, running and cycling and reported no gender differences in pattern of neutrophilia, lymphocytosis, or monocytosis following exercise.[19]

Studies investigating impact of gender on exercise-induced variation in blood cell count is extremely rare in adolescent population. The pattern of gender variation in post-exercise hematological changes in post-pubertal population, especially the sedentary individuals, has not been examined in details. One of the previous studies[2] examined the influence of exercise stress on perturbation in blood cell count among young and older boys and girls belonging to the age group of 12–14 years following cycling exercise. This study reported higher increases in total leukocyte and lymphocyte counts in girls as compared to boys of similar pubertal status. Moreover, Timmons *et al.*[2] examined the gender variation in blood cell count among pediatric subjects having a narrow age gap (i.e., 12–14 years of age) and consequently most of the subjects were either pre-pubertal or early pubertal.[2] Hence, the findings of that study could not clearly predict the impact of pubertal attainment on gender variation in post-exercise hematological alteration among post-pubertal boys and girls. Furthermore, the findings of Timmons *et al.*[2] in pediatric age group clearly contradicted the observation of Sand *et al.*[19] who reported no significant gender difference in young adult subjects.[19] Therefore, it is apparent that different stages of physical and physiological maturation in terms of pubertal status and age are likely to impact gender variation in post-exercise hematological alteration differently.

To the best of our knowledge, no previous study has directly examined and compared the exercise-induced alteration in blood cell count between sedentary post-pubertal boys and girls following high-intensity incremental running exercise. Moreover, literature on exercise-induced perturbations of hematological profile is scanty in Indian context and unavailable in Indian adolescent population. Therefore, the present investigation was aimed to examine the gender differences in baseline hematological parameters as well as high-intensity incremental running exercise-induced changes in total RBC count, WBC count, hematocrit, hemoglobin (Hb) concentration, absolute and relative count of lymphocyte, monocyte, neutrophil, eosinophil, and basophil among sedentary post-pubertal boys and girls.

MATERIALS AND METHODS

Selection of subjects

Sedentary school going post-pubertal boys (n = 22, age = 16.10 ± 0.74 years) and girls (n = 22, and age = 16.04 ± 0.63 years) were randomly sampled for the present study. Sedentary behavior of the subjects was ascertained based on the criteria of Tremblay *et al.*,[20] and World Health Organization,[21] wherein a children belonging to the age group of 5–17 years are considered to be sedentary if the sedentary activities or recreational screen time is more than 2 h/day[20] and the hours of moderate physical activity per day is <60 min.[21] The subjects who were selected for the study spent nearly 8–9 h in sedentary pursuits without any notable physical activity. They did not take part in any physical conditioning or training program. Subjects with history of any major diseases or under any medication were excluded from the study. The female subjects selected for the study did not use any contraceptive. Attainment of puberty in male and female subjects was assessed by Tanner's staging criterion.[22] The reproductive cycle of the female subjects was closely monitored during the study and all the female participants had normal menstrual cycle length. Female subjects performed the exercise protocol during the period of 10–13 days after the beginning of menses. During this period, they were likely to have highest circulating level of estradiol.[23] The subjects did not participate in any physical exercise from 2 weeks before the experimental trials. Standard balanced diet was given to all the participants from 1 month before the experiment following the guidelines of National

Institute of Nutrition, I.C.M.R.[24] The study was approved by the Human Ethics Committee of the Department of Physiology, University of Calcutta and written informed consent was obtained from all the subjects and their parents. The study was conducted from July 2017 to December 2017 at the Sports and Exercise Physiology Laboratory of Department of Physiology, University of Calcutta, India.

Familiarization trial

The familiarization trial was conducted 3 weeks before the experimental protocol to familiarize the subjects as well as to select the speed and inclination of the treadmill at which the subject attained his or her 80% of age-predicted maximum heart rate or HR_{max} (220 – Age in years). Physical examination of the subjects was performed by recording their pre-exercise heart rate, blood pressure and electrocardiograph. The trial involved progressively incremental treadmill (Viasys, Germany) running by increasing the speed (2 km h^{-1}) and inclination (1%) alternatively after every 3 min until 80% of HR_{max} was reached.

Experimental protocol

Subjects reported at 8 AM to the Sports and Exercise Physiology Laboratory after an overnight fast of 12 h. They were asked to take rest for 30 min on an easy chair. A heart rate monitor (Polar, USA) was secured on the subject's chest to monitor the resting, working and recovery heart rates. The pre-exercise heart rate and blood pressure were recorded after the resting period.

Subjects performed warm up exercise at a speed of 3 km h^{-1} at 0% elevation for 5 min, followed by progressive incremental treadmill running with simultaneous change in speed (by 2 km h^{-1}) and elevation (by 1%) alternatively after each 3 min to reach the specific speed and grade that elicited 80% of HR_{max} during the pre-experimental trial. The subjects continued to exercise at that specified speed and inclination until onset of fatigue as indicated by volitional exhaustion.

Blood samples were collected from antecubital vein just before commencement of the exercise trial (T1) and immediately after cessation of exercise (T2) for estimation of different hematological parameters.

Estimation of hematological parameters

RBC count, hematocrit, Hb concentration, total leukocyte count and differential leucocyte count were estimated using Sysmex XT 400i automated hematology analyzer.

Statistical analysis

Statistical Package for the Social Sciences (SPSS, v 20.0; Chicago, IL) was used for the statistical analysis of the data. Data have been presented as mean ± SE. Paired *t*-test was performed separately in each group to locate significant difference between the mean values of hematological parameters measured before and after the exercise. Independent sample *t*-test was performed to locate any significant difference in mean values of the parameters between two groups and also to find out significant inter-group difference in the mean value of percentage change in each parameter following exercise. The level of significance was set at $P < 0.05$.

RESULTS

Physical characteristics, body mass index (BMI), pre-exercise heart rate, blood pressure, running time to exhaustion, and distance covered by subjects during exercise trial are presented in [Table 1]. BMI of the subjects was in the normal range with boys having significantly ($P < 0.05$) higher value as compared to girls. Body height and body mass ($P < 0.001$) were also significantly higher in boys compared to girls. Resting heart rate was significantly ($P < 0.001$) higher in girls. Blood pressure, mean running time to exhaustion and average distance covered during treadmill running did not show any inter-group variation [Table 1].

The pre-exercise and the post-exercise values as well as percentage change in hematological parameters are presented in [Table 2]. Pre- and post-exercise hematocrit and Hb concentration were significantly higher in post-pubertal boys ($P < 0.001$). Pre- and post-exercise RBC count did not differ significantly between the groups. RBC count, Hb and hematocrit also did not change significantly following exercise and no inter-group difference in percentage change was observed for these variables. Absolute leukocyte count increased significantly in both the groups following exercise ($P < 0.001$). However, there was no significant intergroup difference in pre- and post-exercise value as well as magnitude of percentage change in leukocyte count following exercise.

The absolute and relative count of leukocyte subtypes is presented in [Table 3]. Boys had significantly higher pre-exercise absolute monocyte count ($P < 0.01$), while girls had significantly higher baseline absolute lymphocyte count ($P < 0.05$) [Table 3]. There was no significant inter-group difference in baseline value of absolute neutrophil, eosinophil, and basophil count [Table 3].

Significant increase in absolute counts of lymphocyte, monocyte ($P < 0.001$), neutrophil ($P < 0.001$), eosinophil ($P < 0.001$) and basophil ($P < 0.001$) was noted in boys' group following exercise trial. There was also significant increase in absolute lymphocyte ($P < 0.001$), neutrophil ($P < 0.01$), eosinophil ($P < 0.05$) and basophil ($P < 0.01$) count in girls in response to exercise. Post-exercise absolute lymphocyte count as well as percentage increase in this variable was

Table 1: Physical and physiological characteristics of the subjects and running time to exhaustion and distance covered by them.

Groups	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 (km)
					Systolic	Diastolic		
Boys (*n*=22)	158.32±0.86	49.90±0.57	19.97±0.27	70.5±0.91	110.77±0.84	71.45±0.40	50.7±1.7	7.51±0.40
Girls (*n*=22)	153.91±0.71$^{\#\#}$	44.76±0.50$^{\#\#}$	18.90±0.19$^{\#}$	76.09±0.86$^{\#\#}$	112.36±1.37	69.27±1.09	47.46±2.29	6.47±0.38

Values were expressed as mean ± SE, $^{\#}P<0.05$, $^{\#\#}P<0.001$

Table 2: Changes in hematological parameters following exercise.

Variable	Group	Absolute count		Percentage change
		Before exercise	After exercise	
Red blood cell (X 10^{12}/L)	Girls	4.83±0.07	4.85±0.06	0.41±0.40
	Boys	4.97±0.08	5.02±0.08	0.79±0.50
White blood cell (/CUMM)	Girls	8196±317	10426±356*	29.14±4.25
	Boys	8216±213	10072±301*	22.27±1.03
Hematocrit	Girls	36.43±0.32	36.82±0.55	1.32±1.98
	Boys	40.04±0.52$^{\#}$	40.05±0.50$^{\#}$	0.06±0.49
Hemoglobin (g/dl)	Girls	12.14±0.10	12.27±0.18	1.32±1.98
	Boys	13.35±0.16$^{\#}$	13.34±0.17$^{\#}$	−0.009±0.50

Values are expressed as Means ± SE. Negative values indicate decrease. *$P<0.001$ (Significant change within the group from pre-exercise value). $^{\#}P<0.001$ (significant difference between the groups at respective time points)

Table 3: Changes in absolute and relative leukocyte count following exercise.

Variable	Group	Absolute count		Percentage change in absolute count	Relative count (%)		Percentage change in relative count
		Before exercise	After exercise		Before exercise	After exercise	
Lymphocyte (/cumm)	Girls	2433±158$^{\#}$	3492±129***$^{\#\#\#}$	51.91±7.98$^{\#}$	29.50±1.28$^{\#\#\#}$	33.88±1.24**$^{\#\#\#}$	17.35±4.10$^{\#}$
	Boys	1902±137	2505±182***	31.95±1.33	22.734±1.22	24.42±1.27***	7.62±0.39
Monocyte (/cumm)	Girls	191±9	210±7	14.05±5.76	2.34±0.07	2.02±0.01***	−11.98±2.81
	Boys	234±13$^{\#\#}$	266±13***$^{\#\#}$	14.87±2.24	2.82±0.11$^{\#\#}$	2.65±0.12**$^{\#\#\#}$	−5.95±2.08
Neutrophil (/cumm)	Girls	4968±208	5992±278***	20.40±2.01	60.84±1.45	57.28±1.57**	−5.65±1.79
	Boys	5393±120	7029±172***$^{\#\#}$	30.22±1.09$^{\#\#\#}$	66.05±1.31$^{\#}$	70.29±1.33***$^{\#\#\#}$	6.51±0.78$^{\#\#\#}$
Eosinophil (/cumm)	Girls	641±93	755±124*	8.09±8.35	7.24±0.88	6.85±1.05	−17.46±7.32
	Boys	629±38	721±51***	13.27±1.34	8.88±0.43	4.90±0.19***	−42.96±2.77$^{\#\#}$
Basophil (/cumm)	Girls	15±0.89	19±0.44**	28.62±6.69	0.1786±0.0057	0.1788±0.0103	−0.60±3.87
	Boys	15±0.48	17±0.58***	18.12±4.13	0.1800±0.0050	0.1738±0.0079	−3.38±3.41

Values are expressed as means±SE. *$P<0.05$ (Significant change within the group from pre-exercise value). **$P<0.01$ (Significant change within the group from pre-exercise value). ***$P<0.001$ (Significant change within the group from pre-exercise value). $^{\#}P<0.05$ (Significant difference between the groups at respective time points). $^{\#\#}P<0.01$ (Significant difference between the groups at respective time points). $^{\#\#\#}P<0.001$ (Significant difference between the groups at respective time points)

significantly higher in girls as compared to boys ($P < 0.05$). Although, post-exercise absolute monocyte count was significantly higher in boys ($P < 0.01$), intergroup variation in percentage change in monocyte did not depict inter-group variation. Boys reported significantly higher post-exercise absolute neutrophil count ($P < 0.01$) and percentage increase ($P < 0.001$) in this variable as compared to girls. No significant difference with respect to percentage change in absolute eosinophil and basophil count was observed between the groups [Table 3].

Baseline relative lymphocyte count was significantly higher in girls ($P < 0.001$), while pre-exercise relative count of neutrophil ($P < 0.05$) and monocyte ($P < 0.01$) was significantly higher in boys. Relative count of lymphocyte increased significantly in both boys ($P < 0.001$) and girls ($P < 0.01$) with higher post-exercise value ($P < 0.001$) and percentage increase ($P < 0.05$) in girls. On the other hand, relative neutrophil count increased ($P < 0.001$) significantly in boys following exercise, while this variable decreased significantly in girls ($P < 0.01$). Boys reported significantly higher percentage increase in relative neutrophil count ($P < 0.001$). Relative proportion of monocyte decreased significantly in both the groups after exercise ($P < 0.001$). However, no significant intergroup differences were observed in post-exercise value or percentage change in relative monocyte count. Relative eosinophil count decreased significantly in boys ($P < 0.001$) but not in girls. Boys had significantly higher percentage change in relative eosinophil count ($P < 0.01$) as compared to girls. Neither post-exercise value nor percentage change in relative basophil count was impacted by exercise [Table 3].

DISCUSSION

Exercise leads to transient perturbation in blood cell count especially lymphocyte and neutrophil which reflects stress-induced alteration of immune function and inflammatory response to exercise. The present investigation examined the influence of gender on exercise-induced perturbations in blood cell count and hematological parameters among sedentary boys and girls after challenging them with high-intensity incremental treadmill running.

It is apparent from the present study that post-pubertal boys had higher basal Hb and hematocrit as compared to the girls of comparable age. However, there was no significant gender difference in baseline values of RBC and WBC count. Acute high-intensity exercise stress did not result in any significant perturbation in RBC count, Hb, and hematocrit values in both the groups and there was no substantial gender difference in pattern of changes in these parameters following exercise. It was previously reported that exercise leads to RBC damage and hemolysis on account of osmotic and mechanical stress induced by exercise,[11] foot stroke hemolysis,[12,13] and free-radical mediated lipid peroxidation of RBC membrane.[14,15] Such exercise-induced intravascular hemolysis results in increased plasma Hb concentration after the exercise.[25] However, in the present study, it is evident that acute high-intensity concentric incremental running exercise of shorter duration did not induce any significant change in RBC count or Hb among sedentary post-pubertal population which suggested that such exercise stress might not induce substantial damage of erythrocyte neither due to mechanical and osmotic stress nor due to free-radical mediated damage. Although acute high-intensity exercise of shorter duration did not result in significant changes in erythrocyte count and Hb, further studies are required to ascertain how long duration endurance exercise impact these variables.

However, unlike erythrocyte count, the total absolute leukocyte count increased significantly in both the groups. This indicated that exercise resulted in profuse leukocytosis in both the groups in response to exercise stress. Exposure to acute stress such as high-intensity physical exercise had been shown to induce leukocytosis, the extent of which is dependent on duration and intensity of exercise.[1,2,4] Studies suggested that such exercise-induced leukocytosis was mostly caused by release of lymphocyte, monocytes and neutrophil into the circulation in response to exercise stress.[2,5,26] High-intensity exercise leads to an intensity dependent increase in sympathetic activity resulting in increased release of catecholamines such as epinephrine and norepinephrine which are responsible for increased trafficking of immune cells such as lymphocytes into circulation from lymphoid organs such as spleen causing increase in total leukocyte count.[27-29] On the other hand, neutrophils are mobilized into the peripheral circulation in response to exercise mostly from the bone marrow and other marginated pools like lungs leading to profuse leukocytosis.[30] Although post-exercise value and percentage increase in total leukocyte was slightly higher in girls, such intergroup difference was found to be statistically insignificant suggesting that exercise-induced changes in total leukocyte count might not be influenced by gender in this age group.

Examination of WBC sub-types suggested that both baseline absolute and relative lymphocyte count was significantly higher in girls as compared to boys suggesting that the proportion of lymphocyte in circulation may be higher among adolescent girls as opposed to age matched boys. However, the post-exercise value and the magnitude of increase in absolute lymphocyte count as measured by percentage increase in this parameter were significantly higher in post-pubertal girls. Post-pubertal girls reported 51.91% increase in circulating lymphocyte in response to exercise as compared to 31.95% increase in lymphocyte count noted in boys. This indicated that girls are relatively more prone to exercise-induced changes in blood lymphocyte count. Moreover, the post-exercise as well as percentage increase in relative proportion of lymphocyte in circulation was also significantly higher among girls (17.35% increases in girls as opposed to 7.62% in boys). This suggested that not only magnitude of post-exercise lymphocyte trafficking but also the relative proportion of lymphocyte in total leukocyte count remained significantly higher in girls both before and after exercise.

Baseline and post-exercise values of both absolute and relative monocyte count were significantly higher in boys suggesting that the proportion of this leukocyte subtype always remained higher in boys irrespective of exercise stress. Exercise stress led to significant increase in absolute monocyte count in boys but not in girls. However, no significant gender variation in pattern of monocytosis was observed as evident from nearly similar percentage change in absolute monocyte count following exercise. Relative monocyte counts actually decreased in both the groups following exercise. Although, the rate of decline in relative proportion of monocyte in circulation after exercise was slightly higher in girls, such gender difference was not statistically significant. This decline in relative count of monocyte was possibly due to comparatively higher exercise-induced trafficking of lymphocyte in circulation which resulted in decrease in relative proportion of monocyte with respect to total WBC in circulation.

Exercise also caused considerable neutrophilia in both the groups following the exercise trial as evident from significant increase in post-exercise absolute neutrophil count. The previous studies confirmed similar immediate neutrophilia in response to acute exercise.[2] The previous research also indicated that neutrophils are mobilized into the peripheral circulation in response to exercise mostly from the bone marrow and other marginated pools like lungs leading to profuse neutrophilia.[30]

It is also apparent that magnitude of mobilization of neutrophil into circulation in response to exercise stress was significantly higher in boys as evident from higher post-exercise value and percentage increase in absolute neutrophil count in boys. The previous studies indicated that post-exercise elevation in neutrophil count might be an inflammatory response to exercise-induced muscle damage wherein neutrophils are recruited to the damaged muscle fibers to remove the dead tissues.[31] Several studies in the past have indicated that the male subjects are likely to experience higher exercise-induced skeletal muscle damage as compared to girls.[32] Moreover, it has also been suggested that the degree of neutrophil recruitment following exercise is a function of muscle mass of the subjects. Timmons *et al.*[2] previously indicated that the extent of post-exercise neutrophilia might be significantly correlated with fat-free mass in healthy children and adolescents.[2] Therefore, higher the muscle mass of the subjects higher will be the post-exercise increment in neutrophil count. In the present study, the boys had significantly higher BMI as compared to girls. This higher muscle mass among boys might have also accounted for higher recruitment of neutrophil in response to exercise. Therefore, this observed gender difference of higher post-exercise neutrophil response in boys might be attributed to higher muscle mass and degree of exercise-induced skeletal muscle damage and inflammation.

It has also been previously reported that exercise-induced increase in cortisol level may have a direct role in post-exercise neutrophilia and individuals with higher post-exercise cortisol level are likely to have higher exercise-induced neutrophilia.[2,26] Research also indicated that interleukin-6 (IL-6) may be another potential mediator of exercise-induced mobilization of neutrophil into circulation and exercise-induced release of IL-6 from working muscle might also be responsible for elevated secretion of cortisol during acute high-intensity exercise.[33] The previous studies also showed statistical association between post-exercise IL-6 level and neutrophil counts following exercise.[30,31]

Examination of relative neutrophil count also suggested that boys had significantly higher relative proportion of neutrophil both before and after exercise. Relative neutrophil count decreased significantly in girls in response to exercise. On the other hand, there was a significant increase in relative neutrophil count in boys. Gender difference in magnitude of change in relative neutrophil count is also evident form significantly higher percentage increase in this variable among boys. The relative proportion of neutrophil in total leukocyte decreased in girls following exercise possibly on account of comparatively higher rate of mobilization of lymphocyte (lymphocytosis) as opposed to release of neutrophil (neutrophilia) in circulation during exercise. This factor might have accounted for significant decline in relative proportion of neutrophil in total leukocyte count following exercise in girl despite of significant increase in absolute count.

Absolute eosinophil count also increased significantly in both the groups but no gender differences could be noted in exercise-induced trafficking of eosinophil as indicated by similar post-exercise increase in both the groups. However, an important finding is that the relative proportion of eosinophil also declined significantly in both the groups with higher reduction in boys as compared to girls. Since the relative rate of increase in lymphocyte and neutrophil count was much higher in both the groups as compared to exercise-induced trafficking of eosinophil into circulation, there was a decrease in relative proportion of these parameters in total WBC count. Although absolute basophil count increased significantly in both the groups, no apparent gender difference could be noted in absolute or relative count of this variable. Many previous studies have reported that strenuous exercise is associated with incidence of the upper respiratory tract infection,[7,3] hyperresponsiveness, and bronchoconstriction caused by airway mucosal inflammation.[9] Since, eosinophils have been described as one of the pro-inflammatory cells responsible for upper respiratory tract reactions including damage to respiratory epithelium, the increase in eosinophil following exercise may have important implications in exercise-induced reactions in the upper respiratory tract.[9] It has also been suggested that exercise may cause hypoxemia due to increase in histamine level released mostly from basophils.[10] In our study, eosinophil and basophil increased similarly in both the groups which indicate toward the possibility that the risk of post-exercise upper respiratory tract hyper-responsiveness and hypoxemia is likely to be similar in both the groups irrespective of gender and physiological differences between the groups. However, further studies are needed to comment on implications of observed gender variations in eosinophilia and basophilia on respiratory function.

CONLUSION

High-intensity incremental exercise by treadmill running did not induce any significant perturbation in RBC count, Hb, and hematocrit in post-pubertal boys and girls. The extent of post-exercise variation in such parameters might not be influenced by gender in sedentary adolescent subjects. Exercise stress caused substantial perturbation in leukocyte count in both the groups mostly on account of exercise-induced lymphocytosis and neutrophilia. The magnitude of post-exercise trafficking of lymphocyte and neutrophil was significantly impacted by gender. While the girls experienced significantly higher post-exercise perturbation in lymphocyte count, the rate of exercise-induced neutrophil trafficking was substantially higher in boys. Higher post-exercise neutrophil mobilization in boys might be attributed to their higher muscle mass and higher susceptibility to exercise-induced muscle damage. Relatively higher rate of post-exercise trafficking of lymphocyte resulted in considerable reduction in relative neutrophil count in girls. Significant exercise-induced monocytosis was observed only among the boys. However, no apparent gender difference could be noted in extent of monocyte mobilization after exercise. Although absolute eosinophil count increased significantly in both the groups, relative count declined substantially, especially among boys, on account of higher rate of mobilization of lymphocyte and neutrophil. Gender appeared to have insignificant impact on exercise-induced perturbation in basophil count.

Practical applications of the study

The present study added novel insights to exercise physiology literature by depicting gender specific trafficking pattern of blood cells which underscores the gender based variations in exercise-induced inflammatory response. The result of this study will help in understanding the body mass specific release pattern of neutrophil which, in turn, depends on gender-related magnitude of muscle damage. These findings will help the trainers to suggest appropriate exercise protocol based on gender specific risk factor of muscle damage and inflammation as well as to better manage inflammation in both the genders following athletic events. The study also highlighted that there may not be any gender differences in the extent of post-exercise eosinophilia and basophilia. This finding opens up new avenues of research to investigate whether such pattern may have any influence on exercise-induced upper respiratory tract hyper-responsiveness, bronchoconstriction, and allergic manifestations mediated by these blood cells following exercise. This study also highlighted that incremental concentric exercise of endurance nature may not cause any adverse effects on blood RBC and Hb and hence exercise of this intensity and duration is safe for inclusion in training program of sedentary boys and girls.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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