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The Effect of Eight Weeks of Aerobic Training on VO_{2max} and Indices in 30-45 Year Old Non-athlete Women

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Abstract

Purpose: Research has shown that blood components may vary with physical exercises so that some variations may result in anemia in both athletes and non-athletes. The present study aims to investigate the effect of 8 weeks of aerobic training on VO_{2max} and hematologic indices in 30-45 year old non-athlete women in Galugah Township.

Material and Methods: The method of the study is quasi-experimental including a pre-test, post-test and control group. The participants of the study consisted of 30 non-athlete women (Mean age=36.9 yrs, Mean weight=74.09 kg, Mean height=158.30 cm). The training protocol included 8 weeks of aerobic training, 3 sessions a week, each comprising 60 minutes running exercise at 60-70% maximum heart rate. Blood samples were collected and examined both before and after the training protocol. Dependent t test was run to compare the pre-test and post-test results in either group, and independent t test was used to compare the mean scores between the groups (α=0.05).

Results: Following 8 weeks of aerobic training, RDW variations (decreases) was not significant despite significant increases in VO2max, RCB, HCT and Hb as well as significant decreases in iron, ferritin, MCV, MCH and MCHC in the experimental group comparing with in the post-test . Following 8 weeks of aerobic training, VO2max values significantly increased in the experimental group comparing with the control group. Ferritin, iron, RBC, MCV and MCH values significantly decreased in the experimental group in the post-test comparing with the control group whereas Hct, Hb and RDW values increased in the control group comparing with the experimental group, though the variations were not significant. MCHC values non-significantly increased in the control group in the post-test comparing with the experimental group.

Discussion and Conclusion: We report that aerobic training can cause variations in hematologic indices in middle-aged women. Moreover, aerobic training not only exerts a favorable influence upon cardiovascular adaptations, but it is also the most significant factor to increase VO2max in the individual.

Keywords: Aerobic training, Red blood cell, Iron, Ferritin, Hematologic indices

Introduction

Over the last years, physical education specialists and physicians have turned their attention to sports hematology. Blood is considered as a non- uniform connective tissue, containing various components, which principally functions to maintain the uniform structure of internal tissues [1,2]. Blood is primarily a means for transferring oxygen, nutrients, hormones and antibodies to tissues as well as carrying carbon dioxide and the other wastes to excretory organs [3]. Blood components, particularly red blood cells (RBC) and hemoglobin, are primarily responsible for transferring oxygen and nutrients to active tissues and carrying wastes and carbon dioxide to the lungs to be eliminated. On the other hand it is confirmed that increases in VO_{2max} and physical endurance through physical training depend on different factors. One of these factors which seemed to be significantly important is the oxygen-carrying capacity of the blood. Besides, RBC count, levels of hemoglobin, hematocrit, iron and ferritin levels of blood serum are considered as the essential elements in either increasing or decreasing of oxygen-carrying capacity to tissues and eliminating of carbon dioxide [4]. Blood components may vary with

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physical exercises. Some of these changes may result in anemia, commonly caused by iron deficiency [5]. The processes in which Iron supply are discharged may happen rapidly, that it mainly depends on the balance between iron supply and consumption. There is evidence that iron uptake is deficient in women doing physical exercises [6]. Researches have shown a significant positive correlation between the values of hemoglobin, hematocrit and RBC count with VO_{2max} and duration of physical activity [7]. Cardiovascular endurance is one of the measures of physical fitness, which develops with regular aerobic exercise. To reach aerobic fitness, in addition to have a strong heart and lungs with high capacity, some changes should occur in blood and at the cellular level, because the required oxygen of active tissues would increase by raising of physical activity intensity[8]. There are several factors such as training procedure, heredity, training condition, size and body composition, sex and age which influence on maximum Oxygen consumption (VO_{2max}). The value of VO_{2max} usually differs between men and women, which is related to the amount of hemoglobin in the individual. Hemoglobin is the carrier of blood oxygen so that even small changes in hemoglobin or the total hemoglobin mass can have a significant influence on the value of VO_{2max} and endurance exercise performance. Most of the studies done on the effect of aerobic training on VO_{2max} have reported that only aerobic training can result into the increase of VO_{2max} and Significant changes in hematological parameters such as hemoglobin and hematocrit(9-15). Mousavi zadeh et al in their study following 8 weeks of aerobic training and with a heart rate of 60 to 65% have found a significant decrease in Hemoglobin (Hb), Red Blood Cell Count (RBC), Hematocrit (Hct), Iron and Ferritin of Serum and also no meaningful change in Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC) and stated its reasons as the dilution of the blood caused by plasma volume increase and RBC production decrease due to the lack of its precursors and hemolysis of red blood cells and gastrointestinal bleeding [2]. In a study by Fujitsu and et al following 12 weeks of heavy physical training, they have found intravascular hemolysis and iron deficiency as the main cause of Significant 12/2 % and 11/6% reduction of HB and RBC respectively and significant increase of MCV [16]. Karakok and his colleagues, in their study have reported no significant change in RDW and RBC but significant decrease of HB and MCV following 90 minutes of standard soccer training due to increased plasma NP ion which facilitates the transfer of liquid from cells into plasma space [17]. According to the researches, simultaneously with the increase of physical fitness through exercises, it is expected that oxygen-carrying capacity of the blood improved by the changes in blood parameters. However, different meanwhile contradictory findings have turned attentions to the effect of exercise activities with different durations and intensities on hematologic factors of athlete skill levels and its relation to blood components and the range of blood component responses in different sports. Several studies have shown a positive correlation between the amounts of hemoglobin, hematocrit and RBC on the one hand and VO_{2max} , physical exercise duration and exhaustion limit on the other hand. Moreover it should be noted that changes in the amount and size of hemoglobin, hematocrit and RBC are under the influence of the decrease or increase of other factors, especially plasma serum iron levels [18]. As due to cyclical menstrual periods, women are more vulnerable to iron deficiency and consequently reduction in oxygen-carrying capacity of the blood and besides iron deficiency reduces the level of hemoglobin via causing anemia, this may in turn reduce oxygen-carrying capacity of the blood and decrease her performance in the activities that require maximal oxygen consumption[2]. Such researches are very rare especially in relation to women given their particular issues, such as pregnancy and menstruation periods, and besides Mediterranean women, particularly in our country, due to malnutrition or lack of adequate knowledge about nutrition usually suffer from iron deficiency and anemia, which may be deteriorated as a result of exercises particularly endurance training. And at the end, according to the evidences related to optimal levels of physical activity for different age groups, it is not made clear exactly the intensity and volume of aerobic training in order to arise beneficial changes in their blood hematological parameters.Thus, the present study aims to answer the question whether or not 8 weeks of aerobic training brings about biochemical changes in hematologic indices and VO_{2max} especially in

middle-aged women.

Material and Methods

The method of this study is quasi-experimental including a pre-test and post-test with a control group. The population of the study consisted of all (30-45 year old) non-athlete women in the city of Galugah. Among the population, a sample of 30 non-athlete women were selected as the participants based on sex-age characteristics through a health questionnaire provided by Galugah health center, which was divided into two experimental and control groups randomly by matching method of VO_{2max} obtained through (1 mile)1600-meter walking test [19]. Height, weight and subcutaneous fat of subjects of the present study is presented in (table 1). Selection criteria of participants included lack of drug use, diabetes, hypertension, cardiovascular disease and hyperlipidemia.

Data collection

To measure the body weight of the subjects, a weight scale with one kg accuracy, made in Japan by Yagami INC., and to measure their height a height meter, made in Japan by Yagami INC., with 0.1 cm accuracy was used. To measure VO_{2max} in the participants, one-mile (1600 m fast walking) test was applied [20]. All the participants pass this path from beginning to end, and immediately after the 1600 m, walking time of each of them was determined and recorded by a timer (Chronometer). Immediately the person sat on the bench and her heart rate was specified and recorded by pulse meter (Omron) which fastened on her left wrist. Then, by age, weight, time to walk and heart rate after walking, Vo2max [20] were calculated. Note that participants were in follicle period of their menstrual cycle during both sampling. And also the subjects were asked to be fasting before sampling.

Estimation Equation:

VO_{2max}= [132.853-(0.0769×weight)-(0.3877×age) +(6.315+sex)-(3.2649×walkingtime)-(0.1565× heart rate)].

Parameters were considered as follows:

Weight in kg, age in years, sex for women as zero and for men as one, walking time in minutes, Heart rate in minute, and Vo2 max in ml/ kg of body weight.

Training protocol

The experimental subjects participated in 8 weeks of aerobic training, 3 sessions a week, 1 hour each session. The intensity of training was set at 60-70% maximum heart rate [21]. Subjects had been going to gymnasium of the city at 8:00 to 9:00 am. The training of first week was done at a lower intensity rate of 60% Vo2max, and then during 7 weeks with intensity of 70-60%, heart rate reserve was controlled by Omron device. In each session, the participants did warm up exercised including walking and stretch exercise (static and dynamic) for 10-15 minutes. At the end of each training session, cooling down was performed for 7 minutes of slow walking and stretching motions. The aerobic training program for 8 weeks was conducted as follows:

Week 1: alternate slow and fast walking, stretch and jumping exercises

Week 2: two sets of 2-minute running each set included 4 repeats

Week 3: two sets of 3-minute running each set included 4 repeats

Week 4: two sets of 4-minute running each set included 4 repeats

Week 5: two sets of 5-minute running each set included 3 repeats

Week 6: two sets of 6-minute running each set included 2 repeats

Week 7: two sets of 4-minute running each set included 4 repeats

Week 8: two sets of 5-minute running each set included 4 repeats

Participants took 2-3 minutes rest between repeats and 3-5 minutes rest between the sets.

Measurement of blood indices

To measure studied blood indices, while the subjects were in a sitting position, about 2 cc blood was taken from their brachial vein in two phase, 24 h before the beginning of the protocol and 24 h following the end of 8 weeks aerobic training. The research variables were measured following laboratory processing and plasma separation (containing the anti-clotting EDTA). All hematologic variables were measured using a Cell Counter device, model Ms9 made in France, and an ELISA assay.

Statistical analysis

Descriptive statistics including mean, standard deviation, tabulation and figuration was used to

describe, classify and summarize the raw data. Dependent t test was run to compare the pre-test and post-test results in either group, and independent t test was used to compare the mean scores between the groups (α=0.05). SPSS 14 was used to do the statistical analysis.

Results

Table 1 illustrates the descriptive statistics of both experimental and control groups. Table 2 shows the mean and standard deviation of RDW, RBC, Hct, Hb, MCV, MCH, MCHC, iron, ferritin serum and VO_{2max} values in the experimental subjects in both pre- and post-test.Table 3 illustrates the mean and standard deviation of RDW, RBC, Hct, Hb, MCV, MCH, MCHC, iron, ferritin serum and VO_{2max} values in the experimental and control subjects in post-test.

As shown in Table 2, following 8 weeks of aerobic training, a significant increase was observed in the post-test values of VO_{2max}, RBC, Hct and Hb in the experimental subjects comparing with the pre-test values (P=0.001). However, the values of iron (P=0.011), ferritin (P=0.001), MCV (P=0.00), MCH (P=0.00) and MCHC (P=0.03) significantly decreased in the experimental subjects following 8 weeks of aerobic training. RDW values slightly decreased in the experimental subjects though the variation was not statistically significant (P=0.25).

Table 1: Illustrates the descriptive statistics of both experimental and control groups.

Experimental Group	Group control	Particulars body
158/53±3/54	158 /06±6/35	Height(cm)
73/23±11/30	75/07±12/58	Weight(kg)
36/87±4/77	36/93±4/40	Age(year)
39/33±5/03	35/77±6/01	BF (%)
15	15	Persons

Table 2: Mean and standard deviation of Hb, MCV, MCH, MCHC, RDW, RBC, Hct, iron, ferritin serum and VO2max values in experimental group in both pre- and post-test.

Experimental			
P Value	post-test	pre- test	indices
* 0/001	38/37 ± 10/88	49/98 ± 25/20	Ferritin
* 0/011	71/44 ± 20/76	90/34 ± 21/48	Iron
* 0/001	4/75 ± 0/08	4/06 ± 0/07	RBC
* 0/001	39/48 ± 0/61	34/24 ± 0/816	Hct
* 0/001	13 ± 0/205	11/ 34 ± 0/312	Hb
* 0/00	81/20 ±8	84 ± 8/98	MCV
* 0/00	24/24 ± 1/ 75	27/41 ± 2/ 16	MCH
* 0/03	30/14 ± 0/ 90	32/26 ± 1/ 26	MCHC
0/25	9/30 ± 0/83	9/43 ± 1/26	RDW
* 0/001	47/54 ± 4/95	38/98 ± 6/66	Vo2 max

*The difference is significant at the level α=0.05

Table 3: Mean and standard deviation of Hb, MCV, MCH, MCHC, RDW, RBC, Hct, iron, ferritin serum and VO2max values in either group in the post-test

P Value	Experimental Group	Group control	indices
* 0/069	38/37 ± 10/88	78/93 ± 25/20	Ferritin
* 0/026	71/44 ± 20/76	98/23 ± 27/76	Iron
* 0/004	4/75 ± 0/08	7/12 ± 2/48	RBC
0/946	39/48 ± 0/61	29/53 ± 18/7	Hct
0/57	13 ± 0/205	12/ 36 ± 0/161	Hb
* 0/01	81/20 ±8	87/04 ± 3/92	MCV
* 0/04	24/24 ± 1/ 75	28 ± 1/58	MCH
0/94	30/14 ± 0/ 90	32/16 ± 1/20	MCHC
0/30	9/30 ± 0/83	8/96 ± 0/85	RDW
* 0/002	47/54 ± 4/95	39/56 ± 7/44	Vo2 max

*The difference is significant at the level α=0.05

As shown in Table 3, a comparison of indices between the control and experimental subjects showed a significant increase in VO_{2max} values in the experimental subjects (P=0.002). The post-test decrease in the values of ferritin (P=0.069), iron (P=0.026), RBC (P=0.004), MCV (P=0.01) and MCH (P=0.04) was more significant in the experimental group comparing with the control group. The values of Hct (P=0.946), Hb (P=0.57) and RDW (P=0.30) increased in the experimental subjects comparing with the control subjects though the variation was not significant. MCHC post-test values (P=0.94) slightly increased in the control subjects comparing with the experimental subjects though the increase was not statistically significant (P=0.94).

Discussion and Conclusion

The present study set to investigate the changes of hematologic indices (such as RBC, Hct, Hb, MCV, MCH, MCHC, RDW, iron and ferritin serum) and VO_{2max} of individuals in response to 8 weeks of aerobic training. The results of the study showed that this kind of training may significantly affect on hematologic parameters in middle-aged women.

Findings have shown that 8 weeks of aerobic training significantly improved the values of VO_{2max} in the experimental subjects (P=0.001) (Table 2). This is consistent with the findings of Coppola (9) and Koski (10) which confirmed the meaningful increase of VO_{2max} following aerobic training, but inconsistent with the findings of Jordan (22), Judelson (23) and Adachi (24) which proclaimed insignificant changes in VO_{2max} after aerobic training. The main reason for these differences can be related to significant reduction in fat and total body weight and a slight increase in lean body weight in female athletes, differences in age, sex, physical and exercising conditions of the subjects.

The results of this study have shown that 7 to 8 weeks of aerobic training cause a significant increase in the post-test values of RBC, Hct and Hb in the experimental subjects. This is consistent with previous studies that reported heavy physical exercise is effective in the increase of hemoglobin, hematocrit and the number of blood erythrocytes [25]. while the changes and increase of the above variables depend on duration and regularity of exercise as well as external factors and individual fitness. Much more active, longer and be more severe, more changes will cause [23]. Some researchers have reported that physical exercise may not bring about variations in the values of RBC, Hct and Hb. They contend that these changes are independent of plasma volume variations, and related it to the increased reconstruction of RBC and iron transfer from marrow into red blood cells [26-30]. Some other studies have also reported significant decreases in these indices. Researchers contend that plasma volume increase through endurance physical exercise may dilute blood resulting in reduced hemoglobin concentration. It is also claimed that athletes, especially athletes who have long-term activities will also experience some decreases in hemoglobin, hematocrit and red blood cells at their rest time [31,32].

The present findings showed that 8 weeks of aerobic training significantly reduced MCV, MCH and MCHC in the experimental subjects. This is consistent with some previous findings [17, 29, 30] but inconsistent with others (26-29). Tayebi and Qanbari Niaki and et al have observed no significant changes in MCH and MCHC values but a significant increase in MCV values following one session of 1RM resistance training with medium intensity of one repetition maximum. They contend that these changes are independent of plasma volume variations and stated the reconstruction increase of RBC and iron transfer from marrow into red blood cells as its main reasons [26,27]. Schumacher and colleagues also reported decreases in MCV, MCH and MCHC values in elite cyclists, which they attributed these changes to the duration and intensity of training as well as increased plasma volume [32].

The present findings revealed that RDW values decreased following 8 weeks of aerobic training though the variation was not significant (P=0.25), which is consistent [28-30] but inconsistent with [26,27] studies. According to these researchers, RDW may be the indicator of iron-deficiency anemia so that normal concentration of RDW can signal the recharge of morrow iron supply. On the other hand, iron may be substituted to decrease RWD in women who have above-normal RDW and suffer from Anoxia. In general, researches have shown the conflicting responses of erythrocytes to acute exercise. Some studies have not controlled the effect of plasma volume changes and have reported their findings irrespective of this effect. Studies in which plasma volume variations have not been considered, they failed to suggest the definite reasons for increases or decreases in erythrocyte variables. In other words, the observed hematologic variations result from increased plasma volume but not from structural changes. In studies that have not controlled plasma volume variations, erythrocyte changes are independent of plasma volume variations [26-28].

Findings of the present study revealed that 8 weeks of aerobic training significantly decreased the values of iron and ferritin serum in the experimental subjects. This is consistent with the findings of Mousavi Zadeh [2] and Mostahfezian [33] which reported significant decreases in ferritin values following an aerobic training program; however, it is inconsistent with the findings of Flynn [34]. According to these researchers, iron serum may decrease due to such factors as decreased iron in high-fat or high-fiber diets, iron discharge via perspiration, RBC damage, stomach or bladder hemorrhage and blood dilution. Besides, decreased ferritin serum may be associated with higher iron discharge during training and lack of recharge through nutrition so that the body has to draw on natural iron supply (ferritin). Another justification may relate to participants' sex. The present participants were non-athlete middle-aged women who were more vulnerable to iron deficiency due to menstrual cycles or pregnancy, which in turn causes a decrease in ferritin serum. In sum, physical exercise can cause a series of variations in erythrocyte system of peripheral blood cells, which results in increased oxygen-carrying capacity of blood [35]. The inconsistency between the present findings and previous ones may directly relate to participants' age and sex, type and intensity of exercise, duration of exercise, variable socio-economic statuses of the participants, nutrition, menstrual cycle and method of laboratory examinations. Therefore considering the observed changes in the values of iron, ferritin, RBC, MCV and MCH of participants and regarding the potential deterioration of iron deficiency during menstrual cycles and as a result decreased fitness levels of women, and finally given the findings of the present study and the influence of aerobic training on hematological parameters, both athletes and non-athletes are recommended to maintain their hematologic balance during training sessions, competitions and outside competition seasons and consume proper diets rich in iron to prevent anemia caused problems.

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