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Original Research

Response of Plasma Volume and Albumin to a Session of Intense Endurance Activity in Three Body Compositions of Young Non-Athlete Men

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Abstract

Aims: Plasma displacement from vascular space to cellular and interstitial space following an exercise involvement will influence the evaluation of its components in sport physiology studies. Therefore, this study has been aimed to testify the effects of a session of intense endurance activity on plasma volume and Albumin protein with three distinct body compositions.

Methods: The study has been based on a semi-experimental method in three separate groups of thin (n=12), normal (n= 10), and fat (n=12) participants. Selected studied population was young non-athlete men (20 to 25 years). The participants ran a 60 meter distance (two 5 meter paths, two 10 meter paths and two 15 meter paths) for 30 seconds in 6 non-stop rounds. This process continued after 30 second resting until exhaustion for up to 43 rounds. Blood samples were collected once before starting the test and then after finishing the test process. The samples were collected in EDTA tubes to avoid coagulation and immediately after transferring to laboratory, the plasma was centrifuged. To analyze the data, Kolmogorov-Smirnov test, Levene's statistical test, and covariance analysis using SPSS 20 software in the significance level of $p \leq 0/05$ were applied.

Findings: The results revealed that a session of intense endurance activity makes significant reduction of plasma volume and Albumin protein in all tested groups which was more evident in fat body composition.

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Conclusion: Regarding the results, when plasma components are evaluated after an exercise involvement, plasma volume changes should be considered especially in the studies focusing on exercise physiology.

Keywords: Plasma Volume, Albumin, Endurance Exercise, Body Composition.

Introduction

On obesity, the role of doing exercise and sport involvement played, provides valid and precise interpretation of hormonal and biochemical data obtained from the examination of blood samples (Jabbour et al., 2014(a)). During physical activity, plasma displacement from vascular space into intracellular space may be triggered by sweating (Maughan & Shirreffs, 2012) which eventually causes the increase of blood concentration. The study of plasma change procedure and increased blood concentration following physical activity of is of an utmost importance in two ways; 1- plasma volume changes can directly influence evaluations and plasma component levels when each item is studied physiologically (Bloomer & Farney, 2013), 2- which may be the most important one, is its negative effects on exercise function. In this regard, Davis et al. announced that plasma volume reduction during intense exercise can be a destructive factor for interpreting blood lactate changes (Davis, Rozenek, DeCicco, Carizzi, & Pham, 2007). On the other hands, it is demonstrated that intense exercise may be valuable strategy to determine hormonal and metabolic changes in obese people when their health condition is studied (Whyte, Gill, & Cathcart, 2010).

Previous studies have shown extreme plasma volume changes during and after regular exercise, and aerobics (Ernst, Danburger, & Saradeth, 1991; Mc Naughton, 1989) and anaerobic exercise (Collins, Hill, Cureton, & DeMello, 1986; Kraemer, Kilgore, & Kraemer, 1993) especially in long durations with different intensities. During physical activity, plasma displacement from vascular to interstitial space may be induced by sweating (Maughan & Shirreffs, 2012) which finally lead to increasing blood concentration. The study of changes in plasma volume and blood concentration caused by physical activity is important as 1- plasma volume changes can directly affect the plasma component levels and evaluations which are very important in physiological studies and therefore influence data interpretation and 2- plasma volume reduction will negatively affect physical activity (Bloomer & Farney, 2013). In this regard, James et al declared that plasma volume reduction during intense exercise will act as a destructive factor for the interpretation of blood lactate changes (Davis, Rozenek, DeCicco, Carizzi, & Pham, 2007).

Considering the outbreak of obesity and its subsequent effects on inducing various health problems, the conducted studies on obese people may be efficient but inadequate (Kargotich, Goodman, Keast, & Morton, 1998). As the studies on

obese people underestimate the effects of a factor like plasma volume and its changes before and after doing exercise in reaction to hormone and metabolic responses (Georges Jabbour et al., 2014(a)), the induced changes in plasma volume after doing exercise may subject the interpretation of those findings to many changes (Irving et al., 1990).

Albumin is a natural colloid and the main plasma protein. It synthesizes in liver and enters blood circulation (Wada, Takeda, & Kuwahata, 2018). It is responsible for 80 % of plasma osmotic pressure (Moman, Gupta, & Varacallo, 2017). Reduction of plasma volume during physical activity is closely related to the albumin reduction, in a way that after 5 hours of doing exercise, plasma and albumin get back to their starting level (Nagashima, Mack, Haskell, Nishiyasu, & Nadel, 1999). Numerous studies have been done on changes in plasma volume related to albumin following a recovery period in endurance and long-time running (Haskell, Nadel, Stachenfeld, Nagashima, & Mack, 1997; Kay, O'brien, & Gill, 2005; Nagashima, Cline, Mack, Shulman, & Nadel, 2000; Okazaki et al., 2009; Wada, Takeda, & Kuwahata, 2018), whereas the studies on changes in plasma volume immediately after intense exercise are not closely verified (Georges Jabbour et al., 2014(a)). Jabbour et al. compared plasma volume changes following exercise in normal, obese, and fat young men. They reported plasma volume reduction immediately after doing exercise in fat young participants compared to the normal and obese subjects (Jabbour & Iancu, 2014(b)). Bloomer et al compared the changes of plasma volume immediately after physical activity in three various intensities. They reported the reduction of plasma volume after rapid physical activity in all three intensity levels (Bloomer & Farney, 2013). Imai et al considered albumin reduction immediately after exercise regarding the intensity of that exercise (Imai et al., 2005).

Due to the lack of literature on the changes in plasma volume immediately after an intense exercise and the importance of these variations and their effects on calculation of plasma components, we are going to study the effect of an intense endurance activity on changes in plasma volume and Albumin protein in three thin, fat, and normal groups of body compositions.

Materials & Methods

This study has been done based on a "casual-comparative method" in a semi-experimental form of pre-test and post-test plans in three experimental groups. It was certified in IR.USB.REC. 1398.029 code in University of Sistan and Baluchestan ethics committee. The study's population included healthy and young non-athlete men (20-25 years) lived in Zahedan whose blood samples were collected after planning and receiving their written agreement to participate in the study process voluntarily and purposefully. Following a procedure of informing the participants about the study process, exercise type, and taking their written agreement to participate and asking about their personal information and their

health status, they were divided into three distinct groups of thin(n=11), normal(n=11), and fat(n=12) participants according to their body compositions. After completing the related procedures to the verification of the research project in Sistan and Baluchestan University, the researcher started the executive steps. A declaration to participate in a study was distributed in gyms and university, where it was more probable to find participants. After a week, volunteers' names and phone numbers were recorded. After determining the entering criteria to the screening study, participants were selected by considering any history of heart disease, diabetes, asthma, bone fracture, any certain medication usage, mental problems, and the age limitation of 20 to 25 years. Ignoring researcher's advices and avoiding regular participation in exercises made the author to put some subjects aside from the research process. It worth mentioning that ethical principles to participate in study like consent, confidentiality, privacy, protecting from pressures, damages, physical dangers, and informing the subjects about final results were precisely followed.

Exercise Protocol

A repeated high intensity endurance training (RHIET) protocol is applied in this study. Four cones with 5 meter distance are placed in a path. Each participant runs a round trip to cone A (5 meters) after the start command. Round trip running continues from cone A to C (10 meters) and finally the subjects run round trips from A to D cones. Total running distance is 60 meters (two 5 meters, two 10 meters, and two 15 meters), which the subjects should pass in 30 seconds. Every participant must complete 6 non-stop rounds in 30 seconds (180 seconds in every round). Resting time after each round is 30 seconds. The rounds are repeated for 43 times which prolong about 2/5 hours (Rahmaty, Dehghan, Khoramipour, & Saboory, 2015).

Blood Sampling

After determining the participants' body composition and categorizing them into thin, normal, and fat groups, they were asked to attend in Shahid Beheshti gym after 12 hours of night fasting, 30 minutes before sampling. After about 15 minutes of resting, 2 cc of blood was sampled from their brachial vein. Then the participants started their intense endurance training. Immediately after finishing the training session, second samples were collected and were transferred in tubes containing heparin to the laboratory. It should be noted that the samples of each group were collected in a separate day (in three subsequent days in the due time). To lessen interfering factors, all blood samples were gathered in the due time. Each participant had an individual information folder in which his information was recorded.

Body Composition

Weight measurement: Glamour digital speedometer BF-1041-A model was applied to measure the weights. Participants stood on the scale without shoes with their least possible piece of clothing. The measured numbers were recorded.

Height measurement: Before the training, participants' heights were measured in standing posture while their heels and hips were adjusted to the wall.

BMI measurement: body mass index (BMI) is the body mass divided by the square of body height in meter. It was separately recorded for each participant.

Plasma Volume Measurement

It was measured using buffalo equation. To measure plasma volume, blood volume must be measured at first. Therefore, Nadler equation was applied to calculate blood volume (Eskandari & Fashi, 2016).

BV= (13669× H3) + (0/3219×W) +0/06041)

Where BV stands for the blood volume/L, H for height/inch, and W for weight/Ib. As body tissue volume in proportion to the existing fat tissue is different, it is possible to overestimate blood volume in fat subjects and underestimate it in muscular people. Needless to say that formulas using cube are more precise and will minimize error probability, therefore such formula is used in this study (Davis, Rozenek, DeCicco, Carizzi, & Pham, 2007). Buffalo formula is as follows:

PV= BV(1-(0/91)(0/96).VCH/100)

Where PV stands for plasma volume/L and VCH represents vein centrifuged hematocrit (Davis, Rozenek, DeCicco, Carizzi, & Pham, 2007).

The following formula is applied to calculate changes in plasma volume (Peyreigne, Bouix, Fedou, & Mercier, 2001).

%ΔPV=10000(H0-H)/H0(100-H0)

Statistical Analysis

A Kolmogorov- Smirnov test, a paired t-test and a covariance analysis test were respectively used to study date normal distribution, examine intragroup changes and determine differences among the groups. Besides, Bonferroni post hoc test was applied to calculate difference areas among the groups. All statistical analysis steps were followed using SPSS software version 20 in the significance level of $p \leq 0.05$

Findings

Table 1 represents participants' personal information. Table 2 shows the changes in albumin and plasma volume levels in posttest compared to the pre-test. In table 3, plasma and albumin volume averages in the studied groups and ANCOVA test results are shown. Post-hoc test results are presented in table 4.

Table 1- participant information

Variable	Group	N	Mean(±SD)
Age(yr)	Thin	12	22.21(±1.23)
	Normal	10	22.01(±1.45)
	Fat	12	23.08(±0.75)
Height (Cm)	Thin	12	184(±0.23)
	Normal	10	180(±0.89)
	Fat	12	172(±1.06)
Weight (Kg)	Thin	12	60.14(±1.21)
	Normal	10	74.56(±1.54)
	Fat	12	89.12(±1.12)
BMI(Kg/m^2)	Thin	12	16.11(±0.89)
	Normal	10	22.79(±0.79)
	Fat	12	32.89(±1.41)

Table 2- plasma volume and albumin levels in pretest and posttest

Group	**Plasma Volume**			**Albumin**		
	Pretest	**Posttest**	***p*-Value**	**Pretest**	**Posttest**	***p*-Value**
Thin	5.14(±1.22)	4.13(±1.13)	0.002*	4.73(±0.13)	4.52(±0.24)	0.013
Normal	5.19(±1.23)	4.08(±1.45)	0.001*	4.72(±0.07)	4.60(±0.03)	0.001
Fat	5.16(±1.09)	3.23(±1.16)	0.002*	4.90(±0.31)	4.45(±0.33)	0.002

Paired-Samples T test results

Table 3- Data related to the pre-test and post-test variables, and ANCOVA test (covariance analysis)

Test	Group	Sampling time	Mean(±SD)	*P*-Value
Plasma Volume	Thin	Pretest	5.14(±1.22)	0.001*
		Posttest	4.13(±1.13)	
	Normal	Pretest	5.19(±1.23)	
		Posttest	4.08(±1.45)	
	Fat	Pretest	5.16(±1.09)	
		Posttest	3.23(±1.16)	
Albumin(g/dl)	Thin	Pretest	4.73(±0.15)	0.006*
		Posttest	4.52(±0.12)	
	Normal	Pretest	4.72(±0.19)	
		Posttest	4.60(±0.16)	
	Fat	Pretest	4.90(±0.14)	
		Posttest	4.45(±0.22)	

ANCOVA test results, comparison of the average values of post-test variable
*, P≤0.05

Effects of an intense endurance exercise session on plasma volume and Albumin protein of three different body compositions

The results of paired t-test and post hoc test for changes in plasma volume (Figure 1) and albumin level (Figure 2) have shown that: 1- After one session of intense physical activity, both plasma volume and albumin levels decreased in all three groups and 2- the difference between reduced levels following an intense physical activity session was significant in all studied groups.

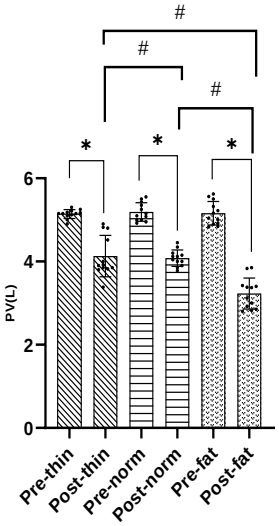

Figure 1: PV changes in study groups. ∗: T test results P≤0.05, #: Boneferoni post-hoc test results P≤0.05.

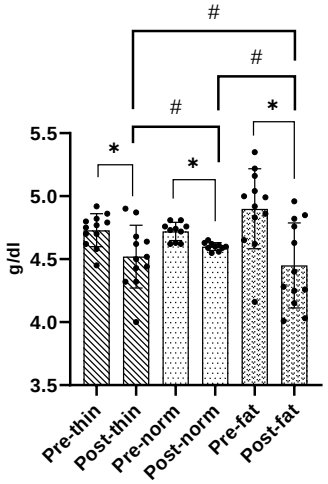

Figure 2: Albomin level changes in study groups. ∗: T test results P≤0.05, #: Bonferroni post-hoc test results P≤0.05.

Therefore, the results of studying thin, fat, and normal body compositions with regard to the plasma and albumin levels proved that changes after an intense endurance activity were extremely significant.

Discussion

The study's results of three distinct groups of fat, normal and thin participants proved a significant difference in plasma volume following an intense endurance exercise. Although fat group participants had shown the increased reduction of plasma level compared to two other studied groups. Our findings correspond many previous studies. For example, Berthoin et al. pointed out to the reduction of plasma volume in adults in response to the intense exercise until fatigue (Berthoin et al., 2002). In addition, Jabbouer et al. (2014) found the same results. They announced the lower levels of plasma volume after doing exercise in comparison to the findings in the resting period. Furthermore, plasma volume in fat subjects reduced more significantly when compared to normal and obese people following an intense endurance activity (Jabbour & Iancu, 2014(b)). Tayebi et al. (2007) concluded with the same findings. They claimed plasma volume following an exercise session reveals significant reduction while it increases to a higher level in recovery (Tayebi & Ghanbari, 2017). This level of plasma reduction may affect physical activity negatively and new strategies for supplying water may be necessary (Bloomer & Farney, 2013) but Shield et al. (2016) found different results. They studied the effects of an intense endurance exercise on plasma protein in endurance athletes compared to non-athlete subjects. Their results indicated that plasma level did not show significant changes (Schild et al., 2016). To verify the difference between what we have found and Shield's findings, differences between exercise protocols can be referred to. In Shield's et al study, participants were asked to drink some water in proportion to their weights during their exercise process. It seems drinking water could prevent plasma volume reduction during and also immediately after their exercise.

Moreover, our findings disclosed that after the intervention albumin levels differ significantly in all studied groups, despite the decrease was greater in the obese body composition group. Post-hoc test results exhibited varieties in related findings to the intended groups. To illustrate plasma stream out of vascular space and reduce plasma volume two mechanisms can be pointed to: 1- increasing blood hydrostatic pressure induced by increasing arterial blood pressure, and 2- increasing metabolic material caused by severe spasms (Davis, Rozenek, DeCicco, Carizzi, & Pham, 2007). In addition to the above mentioned reasons, capillary escape of albumin protein from capillary membrane can be cited, too. Albumin is responsible for 80 % of capillary osmotic pressure (Moman, Gupta, & Varacallo, 2017). Augmenting albumin capillary escape after doing exercise causes the reduction of osmotic pressure and therefore invokes water discharge from the capillary space, and finally leads to the plasma volume reduction

(Haskell, Nadel, Stachenfeld, Nagashima, & Mack, 1997). It is indicated that albumin secretion in urine increases and its secretion directly depends on running distance (Poortmans & Ouchinsky, 2006). In this study, plasma reduction is shown regarding the albumin reduction level. Another effective factor is the increased inflammation caused by Interleukin-6 cytokines (IL-6) and (TNF-α) (Hammond, Hill, & Round, 2019). The intensity of exercise in this study clarifies that inflammation factor is influential in the results. Another effective factor in the verification of obtained results in this study is physiological response of skeletal muscle to sport activities; it has been shown that Oxidative Stress induced by intense exercise causes the reduction of plasma Albumin level (Wada, Takeda, & Kuwahata, 2018). On the other hand, the decreased albumin levels are associated with increased cardiovascular risk (Dziedzic, Slowik, & Szczudlik, 2004). As shown; serum albumin has a clear protective role against cardiovascular disease (Høstmark & Lystad, 2001; Lystad, Høstmark, Kiserud, & Haugen, 1994). Our findings clarified the decrease of plasma albumin levels in all three studied groups of thin, normal, and obese participants. However, this decrease was greater in the group of obese subjects.

The proportion of consumed protein and exercise intensity is among the defining factors of plasma albumin levels following exercise (Wada, Takeda, & Kuwahata, 2018). One of the limitations of this study is overlooking the control of participants' diet.

As far as we know, our study represents the first report on the plasma volume changes and serum albumin levels following a session of resistance exercise.

Conclusion

According to the findings, plasma volume reduced following an intense endurance exercise in the studied groups of fat, normal, and thin participants, despite this reduction is more obvious in the fat subjects. In order to avoid manipulating the results of exercise physiology in evaluation of plasma components after sport involvement, any reduction in plasma volume should be closely studied in all participating groups, especially in fat subjects.

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Conflict of Interest

There is no conflict of interest in regard to this article.

References

1. Berthoin, S., Pelayo, P., Baquet, G., Marais, G., Allender, H., & Robin, H. (2002). Plasma lactate recovery from maximal exercise with correction for variations in plasma volume. *Journal of sports medicine and physical fitness, 42*(1), 26-30.

2. Bloomer, R. J., & Farney, T. M. (2013). Acute plasma volume change with high-intensity sprint exercise. *The Journal of Strength & Conditioning Research, 27*(10), 2874-2878.
3. Collins, M. A., Hill, D. W., Cureton, K. J., & DeMello, J. J. (1986). Plasma volume change during heavy-resistance weight lifting. *European journal of applied physiology and occupational physiology, 55*(1), 44-48.
4. Davis, J. A., Rozenek, R., DeCicco, D. M., Carizzi, M. T., & Pham, P. H. (2007). Effect of plasma volume loss during graded exercise testing on blood lactate concentration. *The Journal of Physiological Sciences, 57*(2), 95-99.
5. Dziedzic, T., Slowik, A., & Szczudlik, A. (2004). Serum albumin level as a predictor of ischemic stroke outcome. *Stroke, 35*(6), e156-e158.
6. Ernst, E., Danburger, L., & Saradeth, T. (1991). Changes in plasma volume after prolonged endurance exercise. *Medicine and Science in Sports and Exercise, 23*(7), 884.
7. Eskandari, A., & Fashi, M. (2016). The response of temporary hypertrophy increase in biceps to four weight training hypertrophy systems in active women.
8. Gleeson, M., Bishop, N. C., Stensel, D. J., Lindley, M. R., Mastana, S. S., & Nimmo, M. A. (2011). The anti-inflammatory effects of exercise: mechanisms and implications for the prevention and treatment of disease. *Nature reviews immunology, 11*(9), 607-615.
9. Hammond, G. L., Hill, L. A., & Round, P. W. (2019). Roles of Plasma Binding Proteins in Modulation of Hormone Action and Metabolism.
10. Haskell, A., Nadel, E. R., Stachenfeld, N. S., Nagashima, K., & Mack, G. W. (1997). Transcapillary escape rate of albumin in humans during exercise-induced hypervolemia. *Journal of Applied Physiology, 83*(2), 407-413.
11. Høstmark, A. T., & Lystad, E. (2001). Lipid peroxidation and growth inhibition of human microvascular endothelial cells. *In Vitro Cellular & Developmental Biology-Animal, 37*(9), 618-623.
12. Imai, H., Era, S., Hayashi, T., Negawa, T., Matsuyama, Y., Okihara, K., . . . Yamada, H. (2005). Effect of propolis supplementation on the redox state of human serum albumin during high-intensity kendo training. *Advances in exercise and sports physiology, 11*(3), 109.
13. Irving, R., Noakes, T., Burger, S., Myburgh, K., Querido, D., & van Zyl Smit, R. (1990). Plasma volume and renal function during and after ultramarathon running. *Medicine and Science in Sports and Exercise, 22*(5), 581-587.
14. Jabbour, G., Curnier, D., Lemoine-Morel, S., Jabbour, R., Mathieu, M.-È., & Zouhal, H. (2014(a)). Plasma volume variation with exercise: a crucial consideration for obese adolescent boys. *Applied Physiology, Nutrition, and Metabolism, 39*(1), 95-100.
15. Jabbour, G., & Iancu, H. (2014(b)). Plasma volume decreases in obese adolescents: An important performance limiting factor during supramaximal exercise.
16. Kargotich, S., Goodman, C., Keast, D., & Morton, A. R. (1998). The influence of exercise-induced plasma volume changes on the interpretation of biochemical parameters used for monitoring exercise, training and sport. *Sports Medicine, 26*(2), 101-117.

17. Kay, B., O'brien, B. J., & Gill, N. D. (2005). Plasma volume expansion 24-hours post-exercise: effect of doubling the volume of replacement fluid. *Journal of sports science & medicine*, *4*(2), 179.
18. Kraemer, R., Kilgore, J., & Kraemer, G. (1993). Plasma volume changes in response to resistive exercise. *The Journal of sports medicine and physical fitness*, *33*(3), 246-251.
19. Krüger, K., Pilat, C., Schild, M., Lindner, N., Frech, T., Muders, K., & Mooren, F. (2015). Progenitor cell mobilization after exercise is related to systemic levels of G-CSF and muscle damage. *Scandinavian journal of medicine & science in sports*, *25*(3), e283-e291.
20. Lystad, E., Høstmark, A. T., Kiserud, C., & Haugen, A. (1994). Influence of fatty acids and bovine serum albumin on the growth of human hepatoma and immortalized human kidney epithelial cells. *In Vitro Cellular & Developmental Biology-Animal*, *30*(9), 568-573.
21. Maughan, R., & Shirreffs, S. (2012). Hydration and performance during Ramadan. *Journal of sports sciences*, *30*(sup1), S33-S41.
22. Mc Naughton, L. (1989). Plasma volume responses associated with a sprint triathlon in novice triathletes. *International journal of sports medicine*, *10*(03), 161-164.
23. Moman, R. N., Gupta, N., & Varacallo, M. (2017). Physiology, Albumin.
24. Nagashima, K., Cline, G. W., Mack, G. W., Shulman, G. I., & Nadel, E. R. (2000). Intense exercise stimulates albumin synthesis in the upright posture. *Journal of Applied Physiology*, *88*(1), 41-46.
25. Nagashima, K., Mack, G. W., Haskell, A., Nishiyasu, T., & Nadel, E. R. (1999). Mechanism for the posture-specific plasma volume increase after a single intense exercise protocol. *Journal of Applied Physiology*, *86*(3), 867-873.
26. Okazaki, K., Hayase, H., Ichinose, T., Mitono, H., Doi, T., & Nose, H. (2009). Protein and carbohydrate supplementation after exercise increases plasma volume and albumin content in older and young men. *Journal of Applied Physiology*, *107*(3), 770-779.
27. Peyreigne, C., Bouix, D., Fedou, C., & Mercier, J. (2001). Effect of hydration on exercise-induced growth hormone response. *European journal of endocrinology*, *145*(4), 445-450.
28. Poortmans, J. R., & Ouchinsky, M. (2006). Glomerular filtration rate and albumin excretion after maximal exercise in aging sedentary and active men. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *61*(11), 1181-1185.
29. Rahmaty, S., Dehghan, P., Khoramipour, K., & Saboory, M. (2015). The Effect of Listening to Brain Waves' Relaxing and Exciting Music during Intense Endurance Training on Blood Cortisol Levels of Adult Men. *American Journal of Sports Science and Medicine*, *3*(4), 77-81.
30. Schild, M., Eichner, G., Beiter, T., Zügel, M., Krumholz-Wagner, I., Hudemann, J., . . . Steinacker, J. M. (2016). Effects of acute endurance exercise on plasma protein profiles of endurance-trained and untrained individuals over time. *Mediators of inflammation*, *2016*.

31. Scott, J. P., Sale, C., Greeves, J. P., Casey, A., Dutton, J., & Fraser, W. D. (2011). The role of exercise intensity in the bone metabolic response to an acute bout of weight-bearing exercise. *Journal of Applied Physiology, 110*(2), 423-432.
32. Simpson, R. J., Lowder, T. W., Spielmann, G., Bigley, A. B., LaVoy, E. C., & Kunz, H. (2012). Exercise and the aging immune system. *Ageing research reviews, 11*(3), 404-420.
33. Tayebi, S. M., & Ghanbari, A. (2017). The Effect of One Session of Eccentric Resistance Exercise on Plasma Viscosity, Lipid Profile andPlasma Lipoprotein in Inactive Male Students. *Sport physiology & management investigations, 9*(2), 157-168.
34. Wada, Y., Takeda, Y., & Kuwahata, M. (2018). Potential role of amino acid/protein nutrition and exercise in serum albumin redox state. *Nutrients, 10*(1), 17.
35. Walsh, N. P., Gleeson, M., Shephard, R. J., Gleeson, M., Woods, J. A., Bishop, N., . . . Hoffman-Goete, L. (2011). Position statement part one: immune function and exercise. Exercise Immunology review, 17, 6-63.
36. Whyte, L. J., Gill, J. M., & Cathcart, A. J. (2010). Effect of 2 weeks of sprint interval training on health-related outcomes in sedentary overweight/obese men. Metabolism, 59(10), 1421-1428.