Original Article

The effect of aerobic and weight lifting exercise on blood clotting

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Abstract:

Aim: The purpose of this study was to examine the effect of an aerobic and weight lifting exercise program in blood clotting. **Study design:** Pre- post measurement after 15 min. and follow up measurement after two hours. **Place and Duration of Study:** Department of Physical Education and Sport Science, Trikala Greece in April 2014. **Methodology:** The sample consisted of 15 undergraduate PE students (9 males M age = 21.56, SD =1.74, and 6 females M age = 21.33, SD =1.86) divided into two groups of 8 (7 males, 1 females) and 7 (5 males, 2 females) participants for the weight and aerobic training program respectively. Two key parameters were selected for measurement and analysis, that is, blood coagulation factor X and thrombin for all participants of both groups. Blood sampling equal to 5ml for each participant was performed prior exercise to verify normal levels of coagulation factors of each individual at rest, after the first 15 minutes of exercise and 2 hours after exercise. **Results:** Results showed that the average amount of factor Xa increased with each new donation while the average amount of thrombin decreased. **Conclusion:** A difference noted was that in the weightlifting training group reduction of thrombin occurred within the first 15' of training remaining stable thereafter, whereas in the aerobic training group reduction of thrombin continued even 2 hours after exercise.

Keywords: weight lifting, aerobic exercise, blood clotting

Introduction

The beneficial effect of aerobic exercise in accelerating the metabolic rate and burn fat, fight obesity and increase blood circulation leading to transfer larger amount of oxygen and nutrients to the muscles has already be proven by research (Hilberg et al., 2013; Mikus et al., 2011; Sand et al., 2013). The increase in aerobic physical activity is now considered a key component of lifestyle modification in order to prevent and treat high blood pressure (Whelton et al., 2002).

Furthermore, a number of studies have been conducted to elucidate the biological relationship between physical activity and haemostatic function and the effect of aerobic exercise on the haemostatic function and fibrinolytic system (Sand et al., 2013). Fibrinogen as a protein produced by the liver and found in blood plasma, contributes to cessation of bleeding, assisting in the formation of thrombi. During coagulation, fibrinogen is converted to fibrin by means of thrombin and ionized calcium. The exercise contributes partly to this coagulation activation leading to a small but significant thrombin generation and activation of fibrinolysis (Mavrovouniotis, 2012; Prisco et al., 1994).

Kumar, Kar and Fay (2011) and Wosornu et al (1992) concluded that aerobic exercise following a coronary bypass that causes drop in fibrinogen concentration increases the success rate of the graft and reduces the chances of myocardial infarction. According to Smith (2003) and El-Sayed, Lin and Rattu (1995), vigorous exercise transiently accelerates blood clotting. However, when a person withdraws from exercise and is at rest, the haemostatic and fibrinolytic system seems unaffected.

Exercise actually leads to increased coagulant and fibrinolytic activity. However, the increased clotting activity is maintained for a longer period of fibrinolytic activity after the end of exercise, therefore, it is very likely to create a more favorable situation for clot formation during this period (Kahraman et al., 2010; Hegde, et al., 2001). El-Sayed et al (2000) concluded that although blood is thick at high rates after strenuous exercise, probably due to the increase of factor VII the levels of other coagulation factors are normal. Exercise in this research significantly reduced thrombin time (TT), while changes in partial thromboplastin time (APTT) and prothrombin time (PT) remained for 1-24 hours after exercise.

Aerobic exercise is not the only one that supports the human body. Weight lifting exercise not only contributes to muscle strengthening and toning and bone restructure, but also to the increase in metabolic rate (Gesarec et al., 2014; Creighton et al., 2013; De Paz et al., 1995). However, its effect on blood clotting has not yet been investigated. All studies carried out with a view to locate the causes of cardiovascular complications

and sudden death occurring immediately after exercise, have solely focused on the effect aerobic exercise to examine the biological relationship between physical activity and haemostatic function (Donde et al., 2013; Sand et al., 2013). Furthermore, the results of these studies are strongly influenced by variables such as the type, intensity and duration of exercise and the methods used for haemostatic evaluation (De Paz et al., 1995; Mikus et al., 2011).

The purpose of this study was to examine the effect of an aerobic and weight lifting exercise program in blood clotting. Most research studies so far examined the effect of aerobic training programs in blood clotting while the effect weight lifting exercise is under presented. The research focuses on the diversity of the effects that these two types of exercise produce on human body as regards to exercise benefits or adverse side effects and intends to find out in which way aerobic and weight lifting exercise can maintain the haemostatic ability of human body in ideal levels.

Method

Participants

The sample consisted of 15 undergraduate students selected randomly for research purposes (9 males Mean age = 21.56, SD =1.74, and 6 females Mean age = 21.33, SD =1.86) of the University of Thessaly / Department of Physical Education & Sport Science, all non-smokers involved in regular physical activity with normal Body Mass Index (BMI). Individuals were randomly divided into two groups of 8 (7 males, 1 females) and 7 (5 males, 2 females) participants for the weight and aerobic training program respectively. All individuals gave their prior consent to participate in pre- and post- blood sampling procedures and the exercise program and they were assured that all collected information would be held strictly confidential. The study was approved by the ethical Committee of the University of Thessaly / Department of Physical Education and Sport Science (No 836).

Experimental Details

Two key parameters were selected for measurement and analysis, that is, blood coagulation factor X and thrombin for all participants of both groups. The blood coagulation factor X frequently encountered in the literature as factor Xa, a symbol used when coagulation factor X is the activated form. Since measurement includes the amount of the activated form of factor X, the notation Xa will be used henceforth in this study. The clotting factor Xa catalyzes the conversion of prothrombin to thrombin. The reason for the selection of the coagulation factor is to study the effect of an aerobic and weight lifting exercise with the reaction that precedes the production of thrombin.

The second coagulation factor chosen for measurement so as to compare the parallel production of coagulation factor Xa and thrombin, was thrombin or coagulation factor II. That is, the last enzyme that takes part in the process of cleavage of fibrinogen into fibrin and enhances the gelling process by acting as a catalyst for the activation of several coagulation factors, such as the coagulation factors V, VII, XI and XII. The method used to study the effect of aerobic and weight exercise with the same thrombin generation was the original method of Western blot, which was developed in the laboratory of AUTH Biochemistry Department. The method of Western blot (or otherwise anisodapoptosis protein), is a widely used analytical technique used for the detection of specific proteins in the test sample (Gerotziafas et. al.2002). For separation of the proteins from the sample mixture gel electrophoresis was used.

Process

The first blood sampling equal to 5ml for each participant was performed before exercise to verify normal levels of coagulation factors of each individual at rest (prior exercise). After the first 15 minutes of exercise followed the second equal sampling while the third blood sampling of 5ml took place 2 hours after exercise. All procedures were conducted at the laboratory of Biochemistry, Aristotle University of Thessaloniki using the following substrates. Factor Xa was evaluated with the use of Rotachron Heperin 4 test kit (Diagnostica Stago, France).Thrombin was evaluated with the use of S2238 Thrombin Substrate, (Anaspec, Europentec grup, CA 94555, USA) with standard procedures.

Blood cells were centrifuged at 400 Xg at a constant temperature + 4 degrees Celsius, separating plasma from the remaining blood components, since coagulation factors move and act in the blood serum. Next, the plasma was stored in a refrigerator at a steady temperature of + 4 degrees Celsius.

Exercise program

1st group (weight lifting).

All three exercises (snatch, clean and jerk and squat) were chosen since they constitute the representative activities of weightlifting sport and their execution involves the activation of almost all muscle groups. In addition, high intensity exercise (1 set × 1 to 4 repetitions per set × 60 to 100% 1 repetition max per exercise) was chosen to increase blood flow in the vessels at a short period of time that in turn causes heart

muscle to respond and raise pulses fast enough to feed blood to muscles. All students were familiarized with weight lifting techniques as they previously attended weightlifting courses included in the undergraduate program of PE studies. In particular:

1st exercise - Snatch: 1 set (s) $\times$ 4 repetitions (re.) $\times$ 60% repetition max (RM), 1s $\times$ 3 re. $\times$ 70% RM, 1s $\times$ 3 re. $\times$ 80% RM, 1s $\times$ 1 re. $\times$ 90% RM, 1s $\times$ 1 re. $\times$ 100% RM.

2nd exercise - Clean and Jerk: 1s $\times$ 4 re. $\times$ 60% RM, 1s $\times$ 3 re. $\times$ 70% RM, 1s $\times$ 2 re. $\times$ 80% RM, 1s $\times$ 1 re. $\times$ 90% RM, 1s $\times$ 1 re. $\times$ 100% RM.

3rd exercise - Squats: 1s $\times$ 4 re. $\times$ 60% RM, 1s $\times$ 3 re. $\times$ 70% RM, 1s $\times$ 3 re. $\times$ 80% RM, 1 $\times$ re 1. $\times$ 90%, 1 $\times$ 1 re. $\times$ 100%. 1 RM.

Break between sets: 1:30 min for 60% to 70% RM and 3 min for 80% to 100% RM.

2nd group (aerobic training).

Aerobic training included aerobic music choreography of 15 minutes, executed at 145 - 152 beats per minute (bpm). Intensity of exercise was located using an oscilloscope (polar) device attached to each participant throughout the 15 minutes of exercise. The ideal aerobic zone for participants of 21-22 years of age was 129 to 159 heartbeats per minute, equivalent to 65% - 80% intensity of their maximum heart rate. Maximum heart rate (MHR) was calculated using the Karvonen (1957) equation, that is, $MHR = 220 - \text{age} \times 60-80\%$ of $HR_{\max}$. Proper aerobic zone boundaries measured in heartbeats were verified at the end of the program. All participants were familiar with aerobic activities since they previously attended aerobic courses included in the undergraduate program of PE studies. Choreography included the following representative aerobic exercises:

- One spot running warm.
- Right step touch, + front step touch right knee with left foot pulling 2 times + scissors + right squat.
- Grapevine right diagonal + grapevine left diagonal + V step + 4 + dimensions behind knees alternating first left front knee + 4 hop back + 2 dimensions land hands.

Results and discussion

Non parametric Wald-Wolfowitz test showed no statistical differentiation regarding factor Xa and thrombin in none of the three check points under investigation between the 2 groups. However, Wilcoxon signed ranks test revealed statistically significant differences between measurements in each group separately.

In particular, as regards to weightlifting training group, the following statistically significant differences between measurements were noted for Xa factor: a) prior exercise - 15 minutes after exercise ($z = -1.965$, $P = .049$), b) prior exercise - two hours after exercise ($z = -2.38$, $P = .017$) and c) 15 minutes after exercise - two hours after exercise ($z = -2.240$, $P = .025$) (table 1).

Table 1. Coagulation factor Xa for weightlifting training group.

Factor Xa				
	Before	After 15'	After 2h	Gender *
1	0,122	0,116	0,131	xx
2	0,133	0,136	0,127	xy
3	0,103	0,104	0,155	xy
4	0,109	0,129	0,142	xy
5	0,164	0,167	0,198	xy
6	0,130	0,139	0,156	xy
7	0,182	0,191	0,195	xy
8	0,129	0,167	0,191	xy
M.O	0,134	0,143	0,161	

*xx for female, xy for male

According to Table 1, following 15 minutes of exercise factor Xa exhibited an increase that continued after 2 hours of exercise in 7 out of 8 individuals, independently of gender. Observing the average values of clotting factor Xa at each blood sampling, it can be assumed that weight exercise increases the content of blood plasma coagulation factor Xa following 15 min and up to 2 hours of exercise.

As for the aerobic training group, no statistically significant differences were noted according to Wilcoxon signed ranks test for factor Xa in any of the three check points of blood sampling (Table 2).

Observing the mean average of coagulation factor Xa for each donation, it can be said that aerobic exercise leads to a slight increase in the content of blood plasma coagulation factor Xa but not up to the point so as to produce statistically significant results.

Table 2. Coagulation factor Xa for aerobic training group.

<i>Factor Xa</i>				
	Before	After 15'	After 2h	Gender
1	0,218	0,151	0,159	xx
2	0,166	0,153	0,027	xx
3	0,001	0,128	0,174	xy
4	0,018	0,179	0,154	xy
5	0,031	0,203	0,272	xx
6	0,129	0,167	0,193	xx
7	0,110	0,108	0,249	xx
M.O	0,096	0,155	0,175	

Statistically significant differences between measurements were also noted for the weightlifting training group as regards to the second parameter measured, that is, thrombin, prior exercise compared to 15' after exercise ($z = -2.366$, $P = .018$) and 2h after exercise ($z = -2.371$, $P = .018$), while no differences between 15' and 2h after exercise were recorded. This was the case for all participants except one case whose blood sample was compromised and therefore the results are not mentioned in the table to ensure reliability (Table 3).

Table 3. Coagulation Thrombin factor for weightlifting training group.

<i>Thrombin</i>				
	Before	After 15'	After 2 h	Gender
1	0,087	0,071	0,054	xx
2				xy
3	0,142	0,027	0,047	xy
4	0,163	0,068	0,144	xy
5	0,051	0,039	0,034	xy
6	0,047	0,028	0,030	xy
7	0,034	0,017	0,008	xy
8	0,157	0,069	0,052	xy
M.O	0,085	0,045	0,045	

After 15 minutes of weight exercise, levels of thrombin in blood plasma significantly reduced throughout the sample while the third bleed discerned that all individuals in the sample exhibited a thrombin drop compared with the initial and second measurement where thrombin was decreased for some individuals whereas in others thrombin values remained stable. Mean average of thrombin factor in each measurement showed that weight exercise affects levels of thrombin leading to an obvious decrease from 0.085 to 0.045 after 15' of exercise, a value that remains steadily decreased up to 2 hours after weight training.

Regarding aerobic training group in relation to thrombin, a significant difference was recorded only between values prior exercise and 2h after exercise ($z = -2.201$, $P = .028$) with no other differences noticed using the Wilcoxon signed ranks test (Table 4).

Table 4. Coagulation Thrombin factor for aerobic training group.

<i>Thrombin</i>				
	Before	After 15'	After 2h	Gender
1	0,028	0,010	0,008	xx
2	0,075	0,098	0,041	xx
3	0,071	0,055	0,060	xy
4				xy
5	0,079	0,061	0,036	xx
6	0,128	0,120	0,071	xx
7	0,244	0,142	0,073	xx
MO	0,104	0,081	0,048	

Following 15' of aerobic exercise, levels of thrombin in blood plasma significantly reduced throughout the sample except in the case of one female participant, whereas the mean average of the third measurement showed that all individuals continued to exhibit a second reduction of thrombin level 2 hours after exercise.

Conclusion

The purpose of this study was to examine the effect of aerobic and weight lifting exercise in blood clotting. The results showed that the average amount of factor Xa increased with each new donation while the average amount of thrombin decreased. Factor Xa catalyses the conversion of prothrombin to thrombin and therefore it should be expected to increase thrombin at each blood sampling.

However, this is not the case due to the anticoagulant mechanisms of the human body. A parallel action of thrombin, in which a receptor is associated with endothelial cells called thrombopoietin, is to inhibit all the action on thrombus formation. In our study, aerobic exercise and weight training affected thrombin, leading to its reduction in blood plasma. The difference noted was that in the weightlifting training group reduction of thrombin occurred within the first 15' of training remaining stable thereafter, whereas in the aerobic training group reduction of thrombin continued even 2 hours after exercise. The lack of correlation appearing between Xa and IIa activity might easily be ascribed to specific inhibitors (i.e. TFPI, ACP, ATIII) released after the appearance of these coagulation factors.

It can be assumed that the human body has the necessary tools to prevent the uncontrolled production process of clot with the increase of factor XA and the subsequent release of inhibitors such as TFPI, antithrombin that lead to a reduction of thrombin levels. This mechanism inhibits all actions for thrombus formation and in any case this mechanism is not functioning properly then the greater possibility for thrombosis formation can be occurred during weight training where a statistically significant increase of coagulation factor Xa was observed 15' and two hours after exercise.

The results of this study agree with the results of El-Sayed et al (2000) who concluded that although after strenuous exercise blood is thick at high rates due to the increase of various coagulation factors, however, the levels of other coagulation factors remains in normal levels (Mavrovouniotis, 2012). Furthermore, the findings of this study are consistent with the results of Kupchak et al (2013), Smith (2003) and El-Sayed, Lin and Rattu (1995) studies, showing that vigorous exercise transiently accelerates blood clotting. However, when a person stops exercise and is at rest, the haemostatic and fibrinolytic system seems unaffected.

Exercise actually leads to an increased coagulant and fibrinolytic activity. However, the increased clotting activity is maintained for a longer period of fibrinolytic activity after the end of exercise, so it is very likely to create a more favorable situation for clot formation during this period after exercise (Menzel & Hilberg 2011; Hegde, et al., 2001). It can be assumed that human body in healthy participants has all the necessary tools to prevent the uncontrolled production process of clot whether they choose aerobic or weightlifting activity.

However, the small sample of the study constitutes a major limitation to extract safe conclusions compared to normal clinical studies of at least 40 samples. Thus, studies with larger samples, different groups according to age and participation in exercise are needed to produce safest interpretation of data.

Ethical Approval

The study was approved by the ethical Committee of the University of Thessaly / Department of Physical Education and Sport Science (No 836).

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

References

- Bloomer RJ, Goldfarb AH, Wideman L, McKenzie MJ, and Consitt LA. (2005). Effects of acute aerobic and anaerobic exercise on blood markers of oxidative stress. *Journal of Strength and Conditioning Research*;19(2):276-285.
- Cesarec G, Martinec S, Basić I, Jakopić D. (2014). Effect of exercises on quality of life in women with osteoporosis and osteopenia. *Coll Antropol*;38(1):247-254.
- Creighton BC, Kupchak BR, Aristizabal JC, Flanagan SD, Dunn-Lewis C, Volk BM, Comstock BA, Volek JS, Hooper DR, Szivak TK, Maresh CM, Kraemer WJ. (2013). Influence of training on markers of platelet activation in response to a bout of heavy resistance exercise. *Eur J Appl Physiol*;113(9):2203-9. doi: 10.1007/s00421-013-2645-4. Epub 2013 Apr 30.

- De Paz JA, Lasier J, Villa JG, Vilades E, Gonzalez-Gallego J. (1995). Effects of aerobic and anaerobic physical conditioning on fibrinolysis. *J Sports Med Phys Fitness*;35(4):263-267.
- Donde A, Wong H, Frelinger J, Power K, Balmes JR, Arjomandi M. (2012). Effects of exercise on systemic inflammatory, coagulatory, and cardiac autonomic parameters in an inhalational exposure study. *J Occup Environ Med*.;54(4):466-70. doi: 10.1097/JOM.0b013e318246f1d4.
- El-Sayed MS, Lin X, Rattu AJM. (1995). Blood coagulation and fibrinolysis at rest and in response to maximal exercise before and after a physical conditioning programme. *Blood coagulation & fibrinolysis*.;6(8):747-752.
- El-Sayed MS, Sale C, Jones PG, Chester M. (2000). Blood hemostasis in exercise and training. *Medicine and Science in Sports and Exercise*;32(5):918-925.
- Gerotziakas GT, Zervas K, Arzoglou P, et al. (2002). On the mechanism of action of recombinant activated VII administered to patient with severe thrombocytopenia and life threatening haemorrhage: Focus on prothrombin activation. *Br. J. Haematol.*;117(3):705-708.
- Hegde SS; Goldfarb AH; Hegde S. (2001). Clotting and fibrinolytic activity change during the 1h after a submaximal run. *Med Sci Sports Exerc.*;33(6):887-892.
- Hilberg T, Menzel K, Wehmeier UF. (2013). Endurance training modifies exercise-induced activation of blood coagulation: RCT. *Eur J Appl Physiol*.;113(6):1423-30. doi: 10.1007/s00421-012-2564-9. Epub 2012 Dec 13.
- Kahraman S, Bediz CŞ, Pişkin Ö, Aksu İ, Topçu A, Yüksel F, & Demirkan F. (2010). The effect of the acute submaximal exercise on thrombin activatable fibrinolysis inhibitor levels in young sedentary males. *Clinical and Applied Thrombosis/Hemostasis*; 1076029610385672.
- Karvonen M, Kentala E, Mustala O. (1957). The effects of training on heart rate: A longitudinal study. *Ann. Med. Exp. Biol. Fenn.*; 35: 307–315.
- Kiyonaga A, Arakawa K, Tanaka H, Shindo M. (1985). Blood pressure and hormonal responses to aerobic exercise. *Hypertension*;7(1):125-131.
- Kumar A, Kar S, Fay W. (2011). Thrombosis, physical activity, and acute coronary syndromes. *Journal of applied physiology*; 111, (2): 599-605.
- Kupchak BR, Creighton BC, Aristizabal JC, Dunn-Lewis C, Volk BM, Ballard KD, Comstock BA, Maresh CM, Kraemer WJ, Volek JS. (2013). Beneficial effects of habitual resistance exercise training on coagulation and fibrinolytic responses. *Thrombosis research*; 131, (6): 227-234.
- Mavrovouniotis F. (2012). Physical Activity and Fibrinolytic Response. *Journal of Physical Education and Sport*.; 12 (4): 482.
- Menzel K, Hilberg T. (2011). Blood coagulation and fibrinolysis in healthy, untrained subjects: effects of different exercise intensities controlled by individual anaerobic threshold. *European Journal of Applied Physiology*.; 111 (2): 253-260.
- Mikus CR, Fairfax ST, Libla JL, Boyle LJ, Vianna LC, Oberlin DJ, Uptergrove GM, Deo SH, Kim A, Kanaley JA, Fadel PJ, Thyfault JP. (1985). Seven days of aerobic exercise training improves conduit artery blood flow following glucose ingestion in patients with type 2 diabetes. *J Appl Physiol*.; 2011;111(3):657-64. doi: 10.1152/jappphysiol.00489.2011. Epub 2011 Jul 7.
- Prisco D, Francalanci I, Filippini M, Hagi MI. (1994). Physical exercise and hemostasis. (*Int J Clin Lab Res.*;24(3):125-131.
- Sand KL, Flatebo T, Andersen MB, Maghazachi AA. (2013). Effects of exercise on leukocytosis and blood hemostasis in 800 healthy young females and males. *World J Exp Med*.;Feb 20;3(1):11-20. doi: 10.5493/wjem.v3.i1.11. eCollection.
- Smith JE. (2003). Effects of strenuous exercise on haemostasis. *Br J Sports Med*.; 37(5):433-435.
- Whelton P, Chin A, Xin X, He J. (2002). Effect of Aerobic Exercise on Blood Pressure: A Meta-Analysis of Randomized, Controlled Trials. *Ann Intern Med*.;136:493-503.
- Wosorun D, Allardyce W, Ballantyne D, Tansey P. (1992). Influence of power and aerobic exercise training on haemostatic factors after coronary artery surgery. *Br Heart J*.;68(2):181-186.