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Comparing the Effect of Diving on Thrombin and Thromboplastin Among Male Divers During Mornings and Evenings

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Abstract: The present study was focused on comparing the effect of diving on thrombin and thromboplastin among male divers during mornings and evenings. In so doing, 10 volunteer divers with a mean age of 32.83±2.63 years, mean weight of 178.83±2.88 cm were selected from among the divers of Red Crescent and Rescue Society of Kohgiluyeh and Boyer-Ahmad Province. To carry out the study, a pre and post-test plan was employed with repeated measurements. The divers swam at 9 am and 3 pm at depths of 10, 20 and 30 for 2 min during 3 days with an intensity of 40-50% of heart rate reservein a to-and-fro way. The participants had safety stop for 5 min at a height of 3 m to the water surface. Before and after diving, 7 cc blood sample was taken from all of the participants. Data analysis were carried out through dependent and independent t-tests using SPSS Software. The results of the experimental examinations and statistical analysis indicated that there was no significant difference between thrombin changes in diving groups in the mornings and evenings ($F_{1, 8} = 1.79$, $p = 0.21$). Moreover, there was no significant difference between the thromboplastin in diving groups in the mornings and evenings ($p = 0.54$). In addition, the results indicated that there was no significant difference between the changes in thrombin and thromboplastin given the increase in the pressures caused by diving in sea depths in both morning and evening groups ($p = 0.09$; $p = 0.06$).

Key words: Diving, thrombin, thromboplastin, morning and evening, Iran

INTRODUCTION

Along with its applications in industry, research and military, diving is done as a sport and recreation. Nowadays, diving sport and recreational diving have become a public activity which is a widely useful, enjoyable and pleasant activity and a source of income in the ecotourism industry. It is important to understand physical laws related to the underwater environment and any wrong selection and inappropriate method can lead to event or even death. Understanding these laws is the basis for how to act under water (Avandi and Tavazo, 2009). According to diving medicine, first carried out by Bacharach and Ekstrom in 1978, bleeding is the death cause of divers. In individuals who do not have the possibility to breathe in normal air, their coagulation capacitywhich is indicated through indices such as fibrinogen or Activated Partial Thromboplastin Time (APTT) increases and fibrinolysis capacity which is determined through increasing indices like plasminogen activator inhibitor type 1 is disrupted (Womack *et al*., 2003). Thrombin or factor 2 is a protein that is needed for coagulation. This enzyme is a serine protease enzyme which converts soluble fibrinogen into insoluble fibrinogen (Hilberg *et al*., 2005). Moreover, thromboplastin is one of the plasma proteins that plays a role in coagulation. Thromboplastin catalyzes the conversion of prothrombin into thrombin (Piccione *et al*., 2005).

Various factors such as age, gender, race, social class, smoking and even seasonal changes can affect hemostasis (Kaeng *et al*., 2003). The type of the activities that individuals carry out causes different coagulation reactions. Research has indicated an increase in the count of platelets and a significant decrease in APTT and lack of significant change in Prothrombin Time (PT) after a session of aerobic exercise. Some studies have reported a decrease in PT and APTT immediately after an aerobic session while some have reported an increase (Habibian *et al*., 2010). This discrepancy in different observations of coagulation after different sports especially in diving and lack of a general agreement indicate the inadequacy of investigations in this regard and the necessity of further studies which leads to posing

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this question, "does diving play a role in coagulation?" Therefore, measuring coagulation factors such as thromboplastin and thrombin as reference parameters.

Tarverdizadeh carried out a study aimed at measuring the effect of maximal and submaximal exercise on coagulation factors (including platelets, hematocrit, coagulation time, partial thromboplastin time and prothrombin time) among non-athlete female students. In that study, the students carried out a maximal exercise (Bruce workout plan, running on a treadmill until exhaustion) and a submaximal one (exercise according to Bruce workout plan up to 75% of maximum heart rate) with a 10 days interval. The results indicated that maximal and submaximal exercises have no significant effect on prothrombin time and coagulation time. It was also indicated that both exercises had a significant effect on hematocrit. Moreover, maximal exercise significantly enhanced partial thromboplastin and submaximal exercise significantly increased the count of platelets. Ghanbari *et al.* (2011) carried out a study aimed at investigating the effect of introverted resistance training on some coagulation factors among inactive men. In that quasi experimental, 12 inactive volunteer students were randomly selected and assigned into an experimental group and a control one. The experimental group carried out a controlled return movement (extension) of elbow flexion including an eccentric contraction. In order to measure coagulation factors, blood sampling was carried out at 30 min before, immediately after and 24 h after the test. The results of the study indicated that there was a significant rise in plasma fibrinogen 24 h after the test ($p<0.05$). However, the intergroup effect and the interaction effect and time were not significant. Prothrombin time did not experience a significant change. The 24 h after the test, the relative activated thromboplastin time had a significant decrease ($p<0.01$). Platelet and its indices did not experience a significant change, either. Marefati *et al.* (2012) conducted a study in order to compare the response of coagulation factors among active and inactive female students to a session of moderate aerobic exercise. That study was a cross sectional intervention that consisted of 22 female students (11 active and 11 inactive students) aged 21-24 studying is Kerman University of Medical Sciences. The results of their study showed that after a session of aerobic exercise, the active individuals' PT (11.45±0.47) was significantly higher than that of the inactive group (11.05±0.43) ($p = 0.050$). However, no significant difference between the active and inactive groups in terms of the variables of PLT ($p = 0.306$), MPV ($p = 0.140$), APTT ($p = 0.082$), fibrinogen ($p = 0.59$) and factor VIII ($p = 0.694$) was observed (Abebi *et al.*, 2011).

Womack *et al.* (2003) investigated critical responses to snowplowing activity with hand and tool among healthy young men. They reported unfavorable changes in critical indices after a session of snowplowing. In a study, Hilberg *et al.* (2005) examined the marginal effect of eccentric treadmill exercise (running down a slope) on thrombin production following exercise and reported thatcoagulation did not activate during pure eccentric exercise. In their study, Menzel and Hilberg (2009) reported that a session of aerobic exercise significantly reduced APTT but caused no change in PT. Peat *et al.* (2010) indicated that APTT dropped immediately after the exercise among both active and inactive individuals.

The present study was aimed at investigating the effect of diving exercise on thromboplastin and thrombin, which is a new and significant issue. Therefore, if a training program causes changes in hemostasis system and modify the response to exhaustive exercise, following it can play a remarkable role in preventing most cardiovascular and cerebral events during or after exercise. Therefore, the main purpose of the present study is to investigate the effect of diving in the morning and evening on coagulation factors.

MATERIALS AND METHODS

According to the purpose of the study, the present study was an applied quasi-experimental investigation. The present study employed a pre and post-test plan. The independent variable of the study was the pressure from the environment caused by daytime diving (morning and evening) and the dependent variables were thrombin and thromboplastin. The statistical population in the present study was the divers of Red Crescent and Rescue Society of Kohgiluyeh and Boyer-Ahmad Province. Ten divers were randomly selected. The selected divers filled out the Health Questionnaire and the Informed Consent Form. In the beginning and before completing the Health Questionnaire, the participants filled out the Informed Consent Form and the Personal Information forms. All of the ten divers were holding CMAS two-star diving license. Moreover, it should be noted that since it is necessary to have knowledge about certain techniques and tricks and skills and certificate in diving, the researcher selected the study sample from among the mentioned individuals. The diving method was like this that the participants swam at the depths of 10, 20 and 30 m for 20 min over 3 days with an intensity of 40% of heart rate reserve. First, blood sampling was taken from the participants (in fasting state). Afterwards, the first and the second groups swam 20 m in a to-and-fro path at the depth of 10 m for 20 min in the morning and evening,

Table 1: Description of the participants' demographic information

Variables	Groups: Diving in the morning	Groups: Diving in the evening
Age (year)	25.83±2.80	26.83±4.30
Height (cm)	173.33±5.88	178.73±2.88
Weight (kg)	77.6±7.160	81.5±7.120

The variables are depicted as standard deviation±mean

respectively. Afterwards, both groups came to the water surface after swimming for 20 min and blood sampling was carried out again. After 24 and 48 h the same exercises were carried out at the depths of 20 and 30 m, respectively and blood samples were taken again. It should be noted that the divers of the two groups were required to swim a distance of 20 m with an intensity of 50-60 max heart rate. It is noteworthy that the participants had safety stop for 5 min at a height of 3 m to the water surface (Ante *et al*., 2007; Abedi *et al*., 2012a). Moreover, Karvonen formula was used in order to determine the intensity of the exercise (40% of maximum heart rate reserve). This study was carried out in Qeshm waters:

Exercise heart rate = 40% (maximal heart rate-resting heart rate)+resting heart rate

In the present study, descriptive statistics methods including mean and standard deviation were employed. Moreover, two-way ANOVA test with repeated measurements was run to analyze the results of the study. The significant level was set at 0.05 ($\alpha = 0.05$) for all tests. In so doing, SPSS Software was utilized (Table 1).

The study's instruments:

- Digital scale Kern (PLS400) made in germany
- Blood sampling tools (Sterile needles and syringes, test tubes, medical cotton, alcohol and glue)
- Stadiometer to measure the participants' height
- Heart rate electrical transmitters (Belt)
- Health questionnaire
- Diving tank (volume: 12 L)
- Regulator
- Buoyancy control device
- Diving mask
- Athletic belt
- Guidance rope for to and froing of the divers under the water
- First-aid kit and oxygen capsule
- Digital depth gauge to measure the depth

RESULTS AND DISCUSSION

Descriptive analysis of the data

Inferential analysis of the data: It is show descriptive anysis of Table 2-4. The results of the data analysis are

Table 2: The results of the statistical analysis of the variables

Groups/activity (m)	Variables	Before diving	Immediately after diving
Diving in the morning			
Depth of 10	Thrombin	16.22±3.47	13.92±1.34
	Thromboplastin	27.360±2.70	27.00±3.39
Depth of 20	Thrombin	13.64±0.42	13.14±0.53
	Thromboplastin	27.16±1.96	28.90±4.00
Depth of 30	Thrombin	12.98±1.30	13.44±86.0
	Thromboplastin	30.60±1.81	29.20±1.30
Diving in the evening			
Depth of 10	Thrombin	13.94±1.70	13.58±1.40
	Thromboplastin	35.00±1.00	35.20±2.48
Depth of 20	Thrombin	13.06±0.36	13.34±0.51
	Thromboplastin	33.00±2.44	33.40±2.07
Depth of 30	Thrombin	13.02±0.35	13.54±0
	Thromboplastin	62.00±48.13	30.75±2.21

The variables are depicted as standard deviation±mean

Table 3: The results of Kolmogorov-Smirnov test to check the normality of data distribution

Statistics/variable (m)	Z-values	Sig.
Thrombin before diving in the depth of 10	0.56	0.91
Thrombin after diving in the depth of 10	0.68	0.74
Thrombin before diving in the depth of 20	0.70	0.70
Thrombin after diving in the depth of 20	0.55	0.91
Thrombin before diving in the depth of 30	0.84	0.45
Thrombin after diving in the depth of 30	0.66	0.77
Thromboplastin before diving in the depth of 10	0.73	0.65
Thromboplastin after diving in the depth of 10	0.77	0.59
Thromboplastin before diving in the depth of 20	0.48	0.97
Thromboplastin after diving in the depth of 20	0.45	0.98
Thromboplastin before diving in the depth of 30	1.66	0.00
Thromboplastin after diving in the depth of 30	0.45	0.92

Table 4: The results of ANOVA test with repeated measurements of thrombin changes at depths of 10, 20 and 30 m

Source of changes	Sum of squares	Average of squares	Degree of freedom	F-values	Sig.
Depth	17.50	8.75	2	8.80	01.06
Depth-group interaction	3.22	3.22	1	1.79	0.21
Error	14.36	1.79	8	-	-
Diving	8.60	4.30	2	2.22	0.14
Diving-group interaction	2.24	1.25	2	0.58	0.57
Error	30.98	1.93	16		
Depth-diving interaction	-	0.38	2	1.37	0.28
Depth, diving, group interaction	0.76	0.38	2	1.36	0.28
Error	4.49	0.28	16	-	-

presented in Table 5. According to these results, an increase in environmental pressure caused by diving at the depths had no significant effect on thrombin changes ($F_{2, 16} = 8.80$, $p = 0.06$). Moreover, there was no significant difference between the morning and evening groups in terms of changes in thrombin caused by an increase in the environmental pressure caused by diving in sea depths ($F_{1, 8}=2.70$, $p = 0.09$). Moreover, the results presented in Table 5 showed that regardless of the increase level in pressure (depth), diving had no significant effect on thrombin ($F_{1, 8} = 0.83$, $p = 0.38$). In addition, there was no significant difference between the morning and evening

Table 5: The results of ANOVA test with repeated measurements of thromboplastin changes at depths of 10, 20 and 30 m

Source of changes	Sum of squares	Average of squares	Degree of freedom	F-values	Sig.
Depth	6.63	3.31	2	0.76	0.48
Depth-group interaction	10.70	52.85	2	12.17	0.06
Error	60.79	4.34	14	-	-
Diving	0.36	0.36	1	0.17	0.69
Diving-group interaction	0.84	0.84	1	0.39	0.54
Error	14.89	2.12	7	-	-
Depth-diving interaction	14.73	7.36	2	1.51	0.25
Depth, diving, group interaction	1.91	0.95	2	0.19	0.82
Error	67.97	4.85	14	-	-

groups in terms of changes in thrombin ($F_{1, 8}$ = 1.79, p = 0.21). On the other hand, the results presented in Table 5 showed that there was no significant interaction between environmental pressure and diving time ($F_{1, 16}$ = 0.58, p = 0.57).

The analysis results presented in Table 5 indicate that an increase in environmental pressure caused by diving at the sea depths had no significant effect on thromboplastin changes ($F_{2, 16}$ = 0.76, p = 0.48). Moreover, there was no significant difference between the morning and evening groups in terms of changes in thromboplastin caused by an increase in the environmental pressure caused by diving in sea depths ($F_{1, 8}$ = 12.17, p = 0.06). Moreover, the results presented in Table 5 showed that regardless of the increase level in pressure (depth), diving had no significant effect on thromboplastin ($F_{1, 8}$ = 0.17, p = 0.69). In addition, there was no significant difference between the morning and evening groups in terms of changes in thromboplastin ($F_{1, 8}$ = 0.39, p = 0.54). On the other hand, the results presented in Table 5 showed that there was no significant interaction between environmental pressure and diving time ($F_{1, 16}$ = 0.19, p = 0.82).

CONCLUSION

According to the results if the present study, diving had no significant effect on men's thrombin in the morning and evening and there was no significant difference between the divers' thrombin in the morning and evening. In other words, diving did not play much role in changes in coagulation. Diving time did not play any role in this regard, either. In other words, time did not play any role in the ineffectiveness of diving on thrombin among male divers and no remarkable changes were observed in coagulation through thrombin no matter what time the divers swim. These findings are in agreement with those reported by Hilberg *et al.* (2005) who reported that coagulation is not activated in pure eccentric active exercise and with the results of the study carried out by Ghanbari *et al.* (2011) who indicated that a session of introverted resistance trainingdid not have a significant effect on changes in platelets and its indices. Therefore, it can be stated that underwaterphysical activities and diving caused no changes in coagulation factors which can be because of the oxygen available in the water, type of clothes, the vest, etc., which cause the coagulation factors will be natural during diving activity. However, the results of the present study and those of the study carried out by Marefati *et al.* (2012) who indicated that after a session of aerobic activity PT of the active individuals was more than that of inactive ones and the results reported by Tarverdizadeh indicated that maximal and submaximal exercises affected coagulation factors (including platelets, hematocrit, coagulation time, partial thromboplastin time and prothrombin time) among non-athletic female students. And the results of the present study are not in line with those of the study carried out by Womack *et al.* (2003) indicated that critical responses to the two activities of snow plowing with hand and tool among healthy young men. This disagreement can be attributed to the difference between the types of the activities carried out in the two studies (Abedi *et al*., 2012b).

Moreover, the results of the present study indicated that diving had no significant effect on thromboplastin among male divers in the morning and evening, i.e., swimming under water in different times and for different durations had no effect on coagulation factors especially on thromboplastin and diving cause no remarkable change in the level of thromboplastin among male divers. This findings are in agreement with those of the study carried out by Hilberg *et al.* (2005) who showed that coagulation was not activated during treadmill exercise. And the results of the present study were in agreement with those of the study carried out by Marefat *et al.* (2012) showed that a session of moderate aerobic activity led to no change in APTT. Therefore, it can be stated that plasma proteins like thromboplastin do not change during diving time and the divers during rest and diving are at the same level in terms of thromboplastin and this is due to the fact that the body temperature do not change or coagulation proteins are in dry and humid state. The results of the study carried out by Ghanbari *et al.* (2011) indicated that a session of eccentric resistance exercise caused the relative activated thromboplastin time had a significant decrease 24 h after the test. The results of the present study are not in line with those reported by

Tarverdizadeh *et al.* (2008) who showed that maximal and submaximal exercise affected partial thromboplastin time among athletic female students and this disagreement can be due to the difference between the statistical populations, number of tests, type of activities and time of activities.

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