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Effects of Diving Experience on Some Biological Variables of Divers

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Abstract:

The current research aims to study the effects of diving for different years on some biological variables of divers. The researchers used the descriptive (survey) approach. The researchers purposefully chose (30) persons divided into divers (n=20) and non-divers (n=10). Divers were subdivided into (5-6) years of diving experience (n=10) and (9-10) years of diving experience (n=10). Non-divers (n=10) are not involved in diving nor any other athletic activity. Results indicated statistically significant differences among the three groups on the post-measurement of biological variables of pulse, diastolic and systolic blood pressure, percentage of CD34+ and cortisol, in favor of the second and third groups. This means that divers (5-6 years and 9-10 years) were better than non-divers.

Key Words: *diving – pulse - blood pressure - CD34+ - cortisol – diving experience*

I. Introduction:

Diving is different from any other aquatic sport. Humans dive for several reasons that may be athletic, commercial, military, scientific explorations of geological or geographic sites, studying marine life in addition to domestic and international tourism. When a person dives, he/she gets into the aquatic medium with purpose of living in it for a limited period of time. This makes the person vulnerable to many risks and pressures of different fluids over the human body. These can affect body systems, especially internal ones, negatively. There are many physical and chemical changes that accompany diving and can induce negative effects on body systems through exposure to high-pressure environment, high density of breathing blend, hyper-oxygenation and breath cold dry air. These two last factors are the most influential in inducing negative effects over the diver's lung function in addition to decreased body temperature and nitrogen micro-bubbles. These factors induce changes in breathing mechanics and cardio-respiratory blood circulation. Continuous diving for farther depths and longer periods increases the probability of inducing negative effects on body vital systems due to increased exposure to such factors (Edmonds et al. 2015; Shopov 2019).

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Those who work under high pressure, like divers, are exposed to massive increase of molecular pressure of oxygen. This is called increase of oxidative stress. In addition, there is an increase of nitrogen molecular pressure. This leads to the formation of silent micro-bubbles inside muscle tissues that remain for several hours after de-pressure and they are transferred to the lungs to be eliminated through exhale as they may cause inflammation in micro-blood vessels of the lung while being eliminated (Konarski et al. 2013).

As a result of regular continuous diving, several adaptations take place in the volume and efficiency of heart muscle. This increases the amount of blood pumped by the heart in each beat which in turn decreases pulse rate. Decreased heart rate and blood pressure at rest and during effect are main characteristics differentiating athletes from non-athletes (Maglischo 2003). Increase of durations for diving and under water training with different depths and pressures lead to biological responses of pressure hormones, especially cortisol that does not completely disappear but becomes more controlled due to adaptations in different sub-systems of the parasympathetic nervous system responsible for hormonal responses activation (Coetzee 2011).

Recently, there are several evidences concerning the clear effect of physical activity on stem cells. Main cells responsible for renewal of heart tissues and blood vessels are identified. Initial evidences indicated that physical training affects mobilization and accumulation of stem cells that form blood vessels and tissues. This in turn increases the physical activity level. Individuals who regularly participate in athletic activities have more available stem cells compared with non-athletes (Bloch &Brixius 2006). Increased pressure over the human body induces physical and chemical changes in the human cell structure. But divers don't feel this massive pressure over their bodies as human tissues contain nearly 65% of water. This leads to an increase in producing stem cells that represent a biological mobilization and repair for all cells that provides cells with the resistance so that they don't crash under pressure (Culic et al. 2014).

During diving to farther depths, the diver is affected by pressure over his/her vital systems. This induces interactions among the nervous system, the immune system and bone marrow that forms stem cells (HSPC) (Sureda et al. 2012). This increases the number of Satellate cells that work on supporting and maintaining muscular cells and all body systems affected by pressure, in addition to increasing body immunity through increasing the number of white blood cells (WBC) (Sureda et al 2012).

Regular physical training improves the cardio-vascular system and muscular system through activating and mobilizing stem cells or accumulating blood stem cells. The increase rate of stem cells depends on the type of physical training and training experience (Sandri et al 2005). Intense exercises and endurance lead to major biological adaptations including, but not limited to, major increase in stem cells production (Gabi et al. 2010). In addition, there is a clear relation between physical exercises and stem cells in adults. It is well-documented that the number of stem cells increases as a result of physical effort and this is related to improving well-being. Physical exercises not only stimulate and mobilize stem cells of the muscular system but can also lead to activating and mobilizing stem cells from bone marrow to the brain and other destinations. These cells help maintaining damaged tissues in the nervous system, the heart, bold vessels, muscles and other body systems (Beausejour 2007; Laura 2008).

Accordingly, under water diving exposes the human body to an environment where surrounding pressures increase as it is different from the air medium where human live. Divers are affected by these pressures and as a result several biological effects take place in all body systems including the cardiovascular system, the respiratory system, the nervous system, the muscular system, the brain and the skeleton. This clearly indicates the significance of studying the effects of diving experience on biology of diver's body. This research problem is clear in in that it tries to identify the biological variables resulting from exposure to under water pressure and if there are any differences in responding to these pressures that are related to diving experience so that we can identify the effects of these variables under investigation on the diver's body as a result of physical loads under different pressures during years of diving.

Aim:

The current research aims to study the effects of diving for different years on some biological variables of divers.

Hypothesis:

There are statistically significant differences in some biological variables after diving among Divers (9-10 years – 5-6 years) and non-divers (sedentary persons).

Approach:

The researchers used the descriptive (survey) approach.

Participants:

Research community included (30) persons including divers (certified by the international diving federation) and non-divers (sedentary persons). The researchers purposefully chose (30) persons divided into divers (n=20) and non-divers (n=10). Divers were subdivided into (5-6) years of diving experience (n=10) and (9-10) years of diving experience (n=10). Non-divers (n=10) are not involved in diving nor any other athletic activity.

II. Data Collection Tools:

According to review of related literature (Jakovljevic 2017; Asmul et al. 2017; Coetzee 2011; Schipke& Pelzer 2001; Mukaerji et al. 2000; Weissinger 2007) for pulse and heart rate fluctuation of divers (Pourhashemi et al. 2016; Zarezadeh&Azarbayjani 2014; Coetzee 2011; McLellan et al 2010) for cortisol (Culic et al. 2014; Sureda et al 2012; Rojas 2010; Gabi et al. 2010; Laura 2008; Wahl & Bloch 2008; Sandri et al. 2005) for stem cells (CD34+), the researchers identified the following variables to be investigated: Pulse – Systolic Blood Pressure – Diastolic Blood Pressure – Cortisol – Stem Cells (CD34+).

Main Study:

Before the study, the researchers verified the following:

- Explaining this study objective to participants.

- All participant signed written consent for their participation.
- All assistants are familiar with methods of measurement and recording data.
- All conditions are suitable for obtaining best results.
- All tools and equipment are valid.

Main measurements were taken at the airlock of department of diving – The Arab Academy for Sciences, Technology and Maritime Transport – Alexandria. All participants performed dry diving (25 m) for 22 minutes using US Navy Dive Schedules to identify max time for this depth.

Statistical Treatment:

The researchers used SPSS Software to calculate the following: Mean – F value – LSD – variance percentage (%).

III. Results:

Table (1): Variance Analysis among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on Biological Variables

S	Variables	Source of variance	Freedom degree	Sum of squares	Means of squares	F
1	Pulse	Intra-groups	2	555.550	277.775	35.435
		Inter-group	27	211.653	7.839	
		Sum	29	767.203		
2	Systolic blood pressure	Intra-groups	2	481.302	240.651	42.851
		Inter-group	27	151.632	5.616	
		Sum	29	632.934		
3	Diastolic blood pressure	Intra-groups	2	353.980	176.990	61.115
		Inter-group	27	78.192	2.896	
		Sum	29	432.172		
4	Cortisol	Intra-groups	2	36.584	18.292	15.475
		Inter-group	27	31.914	1.182	

		Sum	29	68.498		
5	Stem cells (CD34+)	Intra-groups	2	296.066	148.033	45.367
		Inter-group	27	88.101	3.263	
		Sum	29	384.167		

(F) Table value on freedom degrees of 2, 27 and P ≤0.05 = 3.35.

Table (1) showed difference significance among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables. Results clearly indicated statistically significant differences among the three groups.

Table (2): Least Significant Difference (LSD) among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables.

S	Variables	Groups	Means	Means Differences			LSD
				Non-divers	Divers (5-6 years)	Divers (9-10 years)	
1	Pulse	Non-divers	99.000		8.320*↑	12.660*↑	2.567
		Divers (5-6 years)	90.680			4.340*↑	
		Divers (9-10 years)	86.340				
2	Systolic blood pressure	Non-divers	126.330		6.040*↑	8.680*↑	1.511
		Divers (5-6 years)	120.290			2.640*↑	
		Divers (9-10 years)	117.650				
3	Diastolic blood pressure	Non-divers	86.320		5.010*↑	8.320*↑	1.567
		Divers (5-6 years)	81.310			3.310*↑	
		Divers (9-10 years)	78.000				
4	Cortisol	Non-divers	14.530		5.730*↑	6.730*↑	0.996
		Divers (5-6 years)	8.800			1.000*↑	

		Divers (9-10 years)	7.800				
5	Stem cells (CD34+)	Non-divers	59.660		6.020*↑	11.010*↑	2.371
		Divers (5-6 years)	65.680			4.990*↑	
		Divers (9-10 years)	70.670				

Table (2) showed least significant differences (LSD) among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables.

Table (3): Variance Rate among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables.

S	Variables	Groups	Means	Variance Rate		
				Non-divers	Divers (5-6 years)	Divers (9-10 years)
1	Pulse	Non-divers	99.000		8.404	12.788
		Divers (5-6 years)	90.680			4.786
		Divers (9-10 years)	86.340			
2	Systolic blood pressure	Non-divers	126.330		4.781	6.871
		Divers (5-6 years)	120.290			2.195
		Divers (9-10 years)	117.650			
3	Diastolic blood pressure	Non-divers	86.320		5.804	9.639
		Divers (5-6 years)	81.310			4.071
		Divers (9-10 years)	78.000			
4	Cortisol	Non-divers	14.530		39.436	46.318
		Divers (5-6 years)	8.800			11.364
		Divers (9-10 years)	7.800			
5	Stem cells	Non-divers	59.660		10.091	18.455

	(CD34+)	Divers (5-6 years)	65.680			7.597
		Divers (9-10 years)	70.670			

Table (3) showed variance rate among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables.

IV. Discussion:

After measuring the biological effects of diving to 25 m for 22 minutes, it is clear that divers were exposed to physical effort, stress, increased molecular pressure of nitrogen and this exposed their vital systems to pressures that were different from the nature of the air medium where human normal live in. Table (1) showed difference significance among the three groups (non-divers – 5-6 years divers – 9-10 years divers) on biological variables. Results clearly indicated statistically significant differences among the three groups and led the researchers to perform LSD analysis as seen in tables (2) and (3). For pulse, results indicated statistically significant differences between non-divers and divers (5-6 years) in favor of divers (5-6 years) with variance rate of (8.404%). Also, there are statistically significant differences between divers (5-6 years) and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (4.786%). There are statistically significant differences between non-divers and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (12.788%). This clearly indicates that pulse adaptations among divers (9-10 years) are due to long periods of experiences. For systolic blood pressure, results indicated statistically significant differences between non-divers and divers (5-6 years) in favor of divers (5-6 years) with variance rate of (4.781%). Also, there are statistically significant differences between divers (5-6 years) and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (2.195%). There are statistically significant differences between non-divers and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (6.871%). This clearly indicates that systolic blood pressure adaptations among divers (9-10 years) are due to long periods of experiences. For diastolic blood pressure, results indicated statistically significant differences between non-divers and divers (5-6 years) in favor of divers (5-6 years) with variance rate of (5.804%). Also, there are statistically significant differences between divers (5-6 years) and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (4.071%). There are statistically significant differences between non-divers and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (9.639%). This clearly indicates that diastolic blood pressure adaptations among divers (9-10 years) are due to long periods of experiences.

The researchers think that increases in pulse and blood pressure among the three groups are functional responses of body systems, especially the cardio-vascular system, to physical effort under high pressure during diving. Decreased levels of pulse among recreational divers compared with non-divers indicates that divers adapt to different performances. This is an indicators of diver's heart strength compared with non-divers (Smerz 2005; Coetzee 2011). Diving induces several other factors like increased CO_2 molecular pressure and increased breathing effort, compared with the same values under (1 bar) pressure of the surface. This stimulates the parasympathetic system that secrets hormones like Epinephrin and Norepinephrine. These hormones are active during effort leading to an increase in heart rate and blood pressure to provide working muscles with sufficient blood for energy production required for muscular work. This is done through increasing heart rate per minute and the amount of blood pumped from the left ventricle to transferred via arteries and vines to muscular tissues. Fluctuations in blood pressure may be due to changes in the amount of blood pumped by the heart and volume of blood vessels as any increase of the amount of blood pumped by the heart may increase resistance of medium arteries. As a result, the heart increases pumping pressure to force blood into narrow contracted arteries. This increases blood pressure (Asmul et al. 2017; Jakovljevic 2017).

Results also indicated that fluctuations of heart rate for recreational divers who regularly dive are less than irregular divers. This indicates some biological responses resulting from physical effort under water which are clear in decreased levels of heart rate, systolic and diastolic blood pressure at rest due to the increase in the amount of blood pumped by the heart. Experiments of immersion and diving indicated positive effects on the parasympathetic system, the heart and heart rate with the appearance of biological responses resulting from regular diving as pulse, systolic and diastolic blood pressure decrease (Mukerji et al. 2000; Schipke& Pelzer 2001; Coetzee 2011).

As for cortisol, tables (1), (2) and (3) indicated statistically significant differences between non-divers and divers (5-6 years) in favor of divers (5-6 years) with variance rate of (39.436%). Also, there are statistically significant differences between divers (5-6 years) and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (11.364%). There are statistically significant differences between non-divers and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (46.318%). This clearly indicates that cortisol adaptations among divers (9-10 years) are due to long periods of experiences. The researchers think that this increase of cortisol concentrations in serum are due to the increased stress as stress affects the nervous and hormonal systems leading the frontal lobe of pituitary gland to increase the secretion of ACTH which in turn increases the concentration of cortisol from the adrenal cortex. This clearly indicates that stress is higher among beginner divers due to the effects of biological, psychological and mental changes induced by diving pressure and which they are exposed to for the first time. This increases cortisol concentrations (Coetzee 2011).

Divers suffered slight increase of cortisol due to nervous and hormonal adaptation to high pressure environment. But the increase was intense among non-divers due to psychological stress and high pressure over body systems and tissues. This increased ACTH secretion by the pituitary gland. This hormone induces cortisol secretion by the adrenal cortex (McLellan et al. 2010).

Nervous flow from and to nervous receptors are irregular during diving as the diver's body is under water pressure in addition to psychological stress represented in alertness and caution and both of them put the diver's nervous system under stress. Another problem that adversely and directly affects the nervous and hormonal responses is the increase of CO_2 and molecular pressure of oxygen and nitrogen due to increased depth. This stimulates the nervous and hormonal systems to increase secretion of stress hormones to restore balance in body systems to function under high pressure (Coetzee 2011).

Diving stimulates the secretion of stress hormones leading to high levels of of cortisol due to different diving stressors (Coetzee 2011; Zarezadeh&Azarbayjani 2014; Pourhashemi et al. 2016). Cortisol levels increase with the increase of depth due to physical fatigue, increase of gas molecular pressure and increase of pressure over biological systems of divers (Zarezadeh&Azarbayjani 2014). Epinephrine and norepinephrine levels are the most sensitive for the sympathetic system and its activity, in addition to cortisol. They are all effectives means for adapting with high pressure environment (Pourhashemi et al. 2016).

Concerning CD34+, tables (1), (2) and (3) indicated statistically significant differences between non-divers and divers (5-6 years) in favor of divers (5-6 years) with variance rate of (10.091%). Also, there are statistically significant differences between divers (5-6 years) and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (7.597%). There are statistically significant differences between non-divers and divers (9-10 years) in favor of divers (9-10 years) with variance rate of (18.455%). This clearly indicates that CD34+ adaptations among divers (9-10 years) are due to long periods of experiences. The researchers think that these differences are due to the positive effects of physical effort and exposure to different pressures during diving regularly and for long periods as this helped in increasing the number and percentage of CD34+. Diving is an aquatic activity of endurance and high intensity nature. This means it increases regulators of stem cells production and these cells work on increasing the speed of adaptive response to physical loads on the diver's body in addition to maintaining and replacing damaged tissues and this quickens recovery. Stem cells are the major component of muscle fibers, heart fibers, neurons, fibers pool, RBCs, platelets and WBCs. Results confirmed that the two groups of divers were better than non-divers group on the percentage of CD34+. This clearly indicates a relationship between physical effort and stem cells as several studies indicated an increase in the number of stem cells due to physical effort in physically active persons compared with sedentary ones during athletic participation (Sandri et al. 2005; Wahl & Bloch 2008; Laura 2008; Gabi et al. 2010).

Diving plays a positive role in increasing production rates of stem cells in beginner divers. This explains the increase of CD34+ percentage as it is due to participation stress during diving as this stress increases the activation of stem cells to compensate the need of several body systems to replenish themselves from negative effects of physical effort under high pressure conditions of diving. This includes muscular tissues and some hematological components like RBCs and platelets in addition to blood vessels and other body cells affected by pressure. Deep diving exposes divers to high pressure on their vital systems. This induces interactions among the nervous system, the immune system and bone marrow that forms stem cells (HSPC) (Sureda et al. 2012). Diving increases blood stem cells (HSCs) and percentage of stem cells (CD34+ and CD45+) in addition to Primary endothelial cells (EPCs) and vascular endothelial growth factor (VEGF-A). this increase is induced by physical effort related to the nature of diving as a result of body exposure to diving pressure (Zaldivar et al. 2007; Sureda et al. 2012; Culic et al 2014). This indicates that the function of Hematopoietic stem cells (HSCs) in regulating blood cells also contributes in replenishing and maintaining damages in neural fibers and inflammatory processes in other tissues. All processes and catalysts that mobilize and differentiate primary stem cells are responses to exercise and direct physical effort. This increases the concentration levels of stem cells in blood (Hawke 2005; Mori et al. 2008; Rojas 2010).

Accordingly, results indicated statistically significant differences among the three groups on the post-measurement of biological variables of pulse, diastolic and systolic blood pressure, percentage of CD34+ and cortisol, in favor of the second and third groups. This means that divers (5-6 years and 9-10 years) were better than non-divers and this proves the research hypothesis.

V. Conclusions:

According to this research aim, hypothesis, methods and results, the researchers concluded the following:

1. Regular diving for long periods had positive effects on pulse with improvement rates between (4.786%) to (12.788%) in favor of divers (5-6 years) then divers (9-10 years).
2. Regular diving for long periods had positive effects on systolic blood pressure with improvement rates between (2.159%) to (6.871%) in favor of divers (5-6 years) then divers (9-10 years).
3. Regular diving for long periods had positive effects on diastolic blood pressure with improvement rates between (4.071%) to (9.639%) in favor of divers (5-6 years) then divers (9-10 years).
4. Regular diving for long periods had positive effects on cortisol concentrations with improvement rates between (11.364%) to (46.318%) in favor of divers (5-6 years) then divers (9-10 years).
5. Regular diving for long periods had positive effects on stem cells (CD34+) with improvement rates between (7.597%) to (18.455%) in favor of divers (5-6 years) then divers (9-10 years).
6. Increased periods of diving for different depths and pressures had positive effects on pulse, blood pressure and cortisol as it doesn't vanish completely but they become more controlled due to adaptations of of nervous and hormonal systems to high pressure environment.
7. Increased periods of diving had positive effects on the number and percentage of stem cells (CD34+) as it increases with the increase of participation.
8. Pulse rate, systolic/diastolic blood pressure, cortisol concentrations and percentage of CD34+ increased after exposure to high pressure (25 m for 22 minutes at the airlock).

VI. Recommendations:

According to these conclusions, the researchers recommend the following:

1. Creating well-controlled training programs for improving the functional efficiency of divers.
2. Divers should undergo periodic annual (medical/physical) examinations to identify the effects of diving on their bodies over a year of participation.

3. Divers should undergo CD34+ analysis to identify its condition and to consider it when designing training programs for improving their functional and practical efficiency.

4. Performing more studies to identify the effects of regular participation in diving for years on biological responses of different body systems.

5. Performing more studies on biological adaptations of divers and comparing them with other athletes.

6. Performing more studies on the role of stem cells in improving athletic performance in other team and individual sports.

7. Performing more studies to identify the hormones and gens regulating the work of stem cells in elite divers.

References:

1. Åsmul, K., Irgens, Å., Grønning, M., &Møllerløkken, A. (2017). Diving and long-term cardiovascular health. Occupational Medicine, 67(5), 371-376.
2. Beausejour, C. (2007). Bone marrow-derived cells: the influence of aging and cellular senescence. In Bone Marrow-Derived Progenitors (pp. 67-88). Springer, Berlin, Heidelberg.
3. Bloch W, &Brixius K (2006)"Abersichten Sport und Stammzellen, InstitutfürKreislaufforschung und Sportmedizin" ,AbteilungfürMolekulare und ZellulareSportmedizin, Deutsche SporthochschuleKaln.
4. Coetzee, N. (2011). Measurement of heart rate variability and salivary cortisol levels in beginner SCUBA divers: Anthropometry. *African Journal for Physical Health Education, Recreation and Dance*, *17*(Special issue 1), 729-742.
5. Culic, V. C., Van Craenenbroeck, E., Muzinic, N. R., Ljubkovic, M., Marinovic, J., Conraads, V., &Dujic, Z. (2014). Effects of scuba diving on vascular repair mechanisms. *Undersea Hyperb Med*, *41*, 97-104.
6. Edmonds, C., Bennett, M., Lippmann, J., & Mitchell, S. (2015). *Diving and subaquatic medicine*. CRC Press.
7. Gabi ,S. ,et.al (2010) "Reduced number of stem cell of muscle and muscle efficiency of aging and better performance of endurance exercise", stem cell,U.S.A,3,140,
8. Konarski, M., Klos, R., Nitsch-Osuch, A., Korzeniewski, K., & Prokop, E. (2013). Lung function in divers. In *Neurobiology of Respiration* (pp. 221-227). Springer, Dordrecht.
9. Laura D. Bilek, PhD, PT (2008)"Relationship Between Physical Activity and Stem Cells in Older Adults", University of Nebraska Medical Center, U.S.A,
10. Maglischo, E. W. (2003). Swimming fastest: The essential reference on technique. *Training and Program Design, Human Kinetics, Champaign, IL*.p121
11. McLellan, T. M., Wright, H. E., Rhind, S. G., Cameron, B. A., & Eaton, D. J. (2010). Hyperbaric stress in divers and non-divers: neuroendocrine and psychomotor responses. Undersea & hyperbaric medicine, 37(4), 219.

12. Mori, J., Ishihara, Y., Matsuo, K., Nakajima, H., Terada, N., Kosaka, K., ... & Sugimoto, T. (2008). Hematopoietic contribution to skeletal muscle regeneration in acid α-glucosidase knockout mice. Journal of Histochemistry&Cytochemistry, 56(9), 811-817.
13. Mukerji, B., Alpert, M. A., &Mukerji, V. (2000). Right ventricular alterations in scuba divers: findings on electrocardiography and echocardiography. Southern medical journal, 93(7), 673-676.
14. Pourhashemi, S. F., Sahraei, H., Meftahi, G. H., Hatef, B., &Gholipour, B. (2016). The effect of 20 minutes scuba diving on cognitive function of professional scuba divers. Asian journal of sports medicine, 7(3).
15. Radojevic-Popovic, R., Nikolic, T., Stojic, I., Jeremic, J., Srejovic, I., Pesic, G., &Jakovljevic, V. (2017). The Influence of Different Types of Physical Activity on The Redox Status of Scuba Divers. Serbian Journal of Experimental and Clinical Research, 18(1), 19-26.
16. Rojas, M. (Ed.). (2010). Stem cells in the respiratory system", stem cells biology and regenerative Medicine Humana press,Newyork.USA,P98-103.113,2010.
17. Sandri, M., Adams, V., Gielen, S., Linke, A., Lenk, K., Kränkel, N., ... & Schuler, G. (2005). Effects of exercise and ischemia on mobilization and functional activation of blood-derived progenitor cells in patients with ischemic syndromes: results of 3 randomized studies. Circulation, 111(25), 3391-3399.
18. Schipke, J. D., & Pelzer, M. (2001). Effect of immersion, submersion, and scuba diving on heart rate variability. British Journal of Sports Medicine, 35(3), 174-180.
19. Shopov, N. G. (2019). Study of the changes in respiratory function in self-contained underwater breathing apparatus divers. *International maritime health*, *70*(1), 61-64.
20. Smerz, R. W. (2005). Concomitant cerebral and coronary arterial gas emboli in a sport diver: a case report. Hawaii medical journal, 64(1).
21. Sureda, A., Batle, J. M., Ferrer, M. D., Mestre-Alfaro, A., Tur, J. A., & Pons, A. (2012). Scuba diving activates vascular antioxidant system. International journal of sports medicine, 33(07), 531-536.
22. Wahl, P., Brixius, K., & Bloch, W. (2008). Exercise-induced stem cell activation and its implication for cardiovascular and skeletal muscle regeneration. Minimally Invasive Therapy & Allied Technologies, 17(2), 91-99.
23. WeissingerN,(2007)"Bottom Time The Adventures of A Commercial Diver, Acid – Free Paper", U.S.A, 28Fab.,
24. Zaldivar, F., Eliakim, A., Radom-Aizik, S., Leu, S. Y., & Cooper, D. M. (2007). The effect of brief exercise on circulating CD34+ stem cells in early and late pubertal boys. Pediatric research, 61(4), 491-495.
25. Zarezadeh, R., &Azarbayjani, M. A. (2014). The effect of air scuba dives up to a depth of 30 metres on serum cortisol in male divers. Diving Hyperb Med, 44(3), 158-160.
26. 23.Shalaby MN. The Determinants of Leadership: Genetic, Hormonal, Personality Traits Among Sport Administrators. International Journal of Pharmaceutical and Phytopharmacological Research. 2017;7(5):9-14.

27. 24.Shalaby MN. The Effect of Whey Protein (Natural Nanoparticle) on Muscle Strength, GH, IGF, T. Protein and body composition. International Journal of Pharmaceutical Research & Allied Sciences. 2018;7(1).
28. Shalaby MN, Liu JY, Kassem MM, Saad M. Circulating Hematopoietic Stem Cell and Some Physiological Parameters in Different Training Programs. Life Science Journal. 2012;9(1):965-71.
29. Shalaby MN, Saad M, Akar S, Reda MAA, Shalgham A. The Role of Aerobic and Anaerobic Training Programs on CD34+ Stem Cells and Chosen Physiological Variables. Journal of Human Kinetics. 2012;35(1):69-79.