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Cardiovascular Reactions in Response to Water Immersion in Diving and Non-Diving Humans

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Abstract: This study was undertaken to evaluate the reaction of vascular system in response to water immersion in divers and non-divers humans. 30 healthy subjects were divided in to two groups, divers and non divers (15 subjects each). The divers were regularly trained in water, while non-divers were irregularly trained. All participants were subjected to immersion in water for 30 minutes. After the end of immersion time, heart rate, cardio vascular assessment, blood pressure (BP), bradykinin, histamine, LA, potassium, and magnesium concentrations were detected in all subjects. We revealed significant decreases in heart rate, blood pressure with significant increases in histamine, bradykinin, potassium and manganese concentrations in diving subjects when compared to non-diving. In conclusion, divers have a superior vascular system which is quickly adapted to immersion in water compared to the non-divers**.**

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Keywords: Regular training, vascular system, immersion in water, divers, non-divers

1. Introduction

Regular training results in vascular adaptations that enhance perfusion and vascular flow capacity. Intensive physical activity increases the density of the capillary net in the active muscles as well as increases the vascular bed in responses to vasoactive substances. (**Doubt 1996; Amann et al., 2007**). Special cardio vascular adaptations occur in divers, which help them from the medical consequences of diving. As, the diving reflex, is a counterpart of oxygen-conserving reflex that occurs during diving and lead to bradycardia, which means slowing of the heart, peripheral vasoconstriction and anaerobic metabolism, meaning the energy production without Oxygen (**Strauss, Aksenov,2004**). Oxygen is necessary for energy production in electron transport system (**West, 2004**) and oxygen lack leads to vasodilatation in order to preserve O_2 hand over to the acting muscles, which is affected by the exercise grade (**Casey and Joyner, 2012**). Greater Oxygen delivery might increase performance in athletes (**Erichson et al., 1994).** However, the highest degree of hypoxia inhibits performance in comparison to normal Oxygen supply (**Millet et al., 2012**). Decreased performance due to hypoxia as a result of hydrogen ion collection from oxygen lack has been reported (**Eiken and Testh, 1984**).

Immersion in water appears to be the stimulus that initiates the diving reflex (**Gooden, 1994; Barrett et al, 2010**). Regular training may release hormones such as bradykinin and histamine leading to regulation of vascular tone, stimulation of vascular functions and decreasing the sensitivity to the vasoconstriction effects of epinephrine (**Ward, 2008, Hamel, 2006**). Moreover, histamine is an impotant factor in angiogenesis along with vascular endothelial growth factor (**Semenza 2007, Perrotta et al., 2008**).

The aquatic environment drive for added concentration, variance of muscular contraction and coordination while performing aquatic exercise together with enjoy the exercise experience that can lead to longevity, increased cerebral circulation and promote neural structure and growth (**Beilak, 2010, Man et al., 2010**). The effect of systematic physical training on cardio vascular system is a commonly known. But the nature of training induced adaptations is a subject of controversy. Therefore, the aim of this study was to evaluate the reaction of vascular system in response to immersion in water in divers and non-divers.

2. Materials and Methods:

2.1 Research Method: The researcher used the descriptive method of two groups due to the suitability of the study.

2.2 Research sample: 15 Divers were chosen to participate to the study with a training age of 12 years; they were from divers clubs in Hurghada. 15 non-divers participate for the study as control and 4 divers for the pilot study. The control group did not trained regularly. The main study was performed in Hurghada by immersion of the divers for 30 min in water.

2.3 Data Collection Tools:

Height: using restameter

Weight: using medical scale

BMI: using weight/ height2

Heart rate: using stethoscope

Blood pressure using stethoscope + Sphygmomanometer cardio vascular assessment by (**Cooper 1980**)

Assessment of cardio vascular system (endurance) 12 min. swimming in pool lanes 25 meter. LA using AccuSport

Bradykinin and Histamine were estimated using ELISA kits according to manufacturer's instructions.

Potassium and magnesium ions were measured using atomic absorption.

All blood samples were drawn by a specialist, centrifuged and serum samples were stored at -20 ^{o}C until analysis.

2.4: Pilot Study:

Four Divers participated in this study; the divers were from the same group of the study for a period of 3 days.

2.5 Statistical Analysis:

Using the statistical package for the social sciences (SPSS) and expressed as:

A.mean

Standard deviation

Median

T test

Skewness

Differences between experimental (divers) and control groups were assumed to be significant at $p < 0.05$.

3. Results:

Table (2) revealed decreased heart rate, blood pressure and increased assessment of cardio vascular system pressure in divers compared with the control group (non-divers).

Table (3) indicated increased levels of bradykinin and histamine as well as potassium and magnesium ions in divers compared to control group.

Table (1) Homogeneity of the Samples.

Variables	Units	A.Mean	Median	SD	Skewness
Age	Years	32.4	32	1.3	1.2
Height	Cm	176.5	175	1.4	0.9
Weight	Kg	77.4	77.3	2.1	1.4
BMI	Kg/m2	22.3	22.2	1.2	0.84
Heart Rate	C/ mi	72	72	301	0.71
Cardio Vascular assessment	Meters	592	590	13.6	1.3
Blood pressure	sist. mm/merc.	122	122	206	1.1
	Diast. mm/merc	82	82	2.5	0.8
Bradikinin	pg/ml	102	101	9.4	1.5
Histamine	pg/ml	87	86	5.1	1.3
Potassium	mmol/L	4.6	4.4	0.3	0.59
Magnesium	Mg/dl	2.7	2.6	0.5	0.78
LA	mmol/L	1.6	1.63	0.4	0.82

N=30

Table (2) Cardio vascular changes in divers and control group after immersion in water

Variables	Divers M SD		Control M SD		Significance
Heat rate (c.min)	68	7.1	71	1.5	S
Blood pressure	118	2.2	120	1.9	S
(mm/ mercury)	78	1.6	80	1.8	S
Cardiac assessment (meters)	624	9.2	568	8.4	S

Table (3) Hormonal and ions concentration changes in divers and control after immersion in water

Variables	Divers M SD		Control M SD		Sig
Bradykinin (pg/ml)	117	901	89	802	S
Histamine (pg/ml)	91	7.4	78	67	S
Potassium (mmol/l)	5.3	1.1	4.4	1.2	S
Magnesium (mg/de)	3.2	09	2.5	1.1	S

LA (mmol/l)	**1.1**	**0.5**	**1.8**	**0.7**	**S**

4. Discussion:

The present study showed decreased heart rate, Blood pressure decreased and increased assessment of cardio vascular system pressure, in diver subjects. The decreased heart rate in divers may be due to the effect of training on parasympathetic nervous system leading to decreasing heart rate count, which also affect blood pressure and hence lowering blood pressure remarkably. However, cardiac output did not changed in divers compared with the control group, as decreased heart rate was compensated by a higher stroke volume so the lower heart rate together with a higher stroke volume resulted in an equal cardiac output in divers and control group, which was in agreement with previous studies, which demonstrated that the cardiac muscle and heart mass increase due to the adaptation of exercise training regularly with increased blood flow to different organs of the body specially the skeletal muscle, delivering more oxygen all over the body which in turn affect fatigue symptom, that's why the higher the level of the athlete the higher the retard of fatigue, which is an important index of the fitness of the athlete (**Guyton et al., 1973, Schnerman 2002, Taneka and Seals, 2003**).

In the present study, assessment of cardio vascular system (Table 3) indicated that divers were superior (624 meters Compared to control group 568 meters), meaning a good results of the divers compared to fair ones for the control group, this was also reported by Cooper (1980), who stated that swimming assessment is a suitable test to assess cardio vascular endurance for athletes. Adaptation to exercise include different cardiovascular regulatory mechanisms as vasodilatation, fall in blood pressure, an increase in blood storage in venous reservoirs and a decrease in heart rate due to the stimulation of the vagal innervation of the heart have been reported. In addition to other factors affecting vasodilatation namely bradykinin, prostaglandins, epinephrine, potassium and magnesium, and histamine (**Haddy et al., 2006; Paffelt and Walker, 2007; Squire et al., 2008**), which are in accordance with the results of this research. Kinins like bradykinin and histamine increased with exercise was also reported (**Campbell and Gauthier 2002, Davis and Hill 1999, Erdos and Marcic 2001, Guyton and Hall 2006**).

Immersion in water may enhance vasodilatation of blood vessels and venous return to the heart, as veins and venous blood flow are highly affected by the external pressure, including muscular compression and hydrostatic pressure, this immersion results in a net increase in central venous pressure leading to a greater return of blood to the heart that shifts the heart rate downward and a more efficient vascular system obtained (**Sherlock et al, 2013, Becker and Cle, 2011**). We also demonstrated significant increases in concentrations of potassium and magnesium in divers subjects compared to control group as potassium and magnesium are powerful ions inducing vasodilatation of the blood vessels as both inhibit relaxation of the smooth muscle. Decrease PH of the blood and muscle induces the same effects (**Losordo and Dimmeler 2004; Kerbel and Folkman, 2002**).

In Conclusion:

Regular training of the divers included a superior vascular system adaptation compared to non-divers control. It is recommended to train regularly as it's important for the general health specially cardio vascular system.

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