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Electrocardiographic Changes in Scuba Divers: A Quasi-Experimental Study in Iran

Seyyed Mahdi ZiaZiabari[1], Payman Asadi[1], Maryam Shakiba[2], Alireza Habibi[3], Asghar Shokrollahi[3], Jabar Seidshekan[4], Amir Noyani[5], Ilnaz Tavakoli[1*]

[1] Department of Emergency Medicine, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran.
[2] Guilan Road Trauma Research Center, School of Health, Guilan University of Medical Sciences, Rasht, Iran.
[3] Department of Basic Sciences, Faculty of Science, Imam Khamenei University, Zibakenar, Rasht, Iran.
[4] Department of Diving, Faculty of Marine, Imam Khamenei University, Zibakenar, Rasht, Iran.
[5] Clinical Research Development Unit, Imam Hossein Hospital, Shahroud University of Medical Sciences, Shahroud, Iran.

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Abstract

Background: *Cardiac arrhythmias, conduction abnormalities, congenital and acquired heart disorders could threat the human life in scuba diving. This study purpose was to investigate and analyze the electrocardiographic changes in scuba divers.*

Methods: *This quasi-experimental study was accomplished on scuba divers of saltwater in the Persian Gulf. Electrocardiogram (ECG) was taken during 10 min before, immediately and also by passing 60 min from diving. All ECGs were interpreted by an emergency medicine specialist regarding heart blocks, sinus arrhythmia and the heart rate changes, QT and PR intervals, QRS complex, ST segment and T wave. All statistical analyses were performed using SPSS software ver19. Significant level was set at 0.05.*

Results: *37 males with the mean age of 35.7±4.27 years old were enrolled in this study. There was observed no significant change in the mean of the heart rate, mean of the QT interval and T wave change between two age groups cases (<35 and >35 years old), BMI groups (<25 and >25 kg/m2), depth of water groups (<25 and >25 m) and water temperature groups (14 to 15 and 16 to 17 ℃), in the studied time periods (P.V> 0.05, in all of the cases); but the mean of the pulse rate, mean of the QT interval and T wave change indicated significant difference between the studied time periods (P.V=0.005, 0.001 and 0.001, respectively).*

Conclusions: *This study indicated significant changes in pulse rate, QT intervals and T waves between studied periods in scuba divers; consequently, special attention to these changes is required.*

Keywords: Scuba diving, Electrocardiography, Heart rate, Iran.
***Corresponding to:** I Tavakoli, **Email:** ilnaz.tavakol@gmail.com
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Introduction

Scuba diving is an underwater swimming type that performed by the use of a self-contained breathing apparatus and, nowadays, is identified as a modern and communal exercise, but it could also be dangerous and resulted in clinical complications and even death, in some cases.[1] Cold-water diving, high environmental pressure, high inhaled gases partial pressure, increased airway resistance, increased resistance to movement and body's physiological responses to these stresses are recognized as some of this exercise health risk factors.

Several researches have indicated that after arterial gas embolism and choking, the cardiovascular attacks are in the third place of leading causes to death in scuba divers. These investigations have reported that 24% of these attacks occur at the time of entering to the water, 46% of them underwater and also 20% occur after the deep water leaving.[3]

Cardiac arrhythmias, conduction abnormalities, congenital and acquired heart disorders could be considered as life threatening in scuba diving.[3] Ventricular tachycardia is one of the dangerous acquired cardiac arrhythmias, which must be evaluated in scuba divers. Long QT syndrome is a specific ventricular tachycardia form causing torsade de pointes and ventricular fibrillation, can result in sudden death during swimming or going deep down to the water.[4] Additionally, Wolff-Parkinson-White syndrome is also known as one of the important congenital cardiac conduction abnormalities, which could lead to scuba divers death, so it should be noted.[3] On the other hand, pulmonary barotrauma and decompression sickness are arterial gas embolism causes in divers, which can be indicated by the cardiopulmonary symptoms and also sudden death.[5] In addition, some of the other heart complications in scuba divers are as followings: right ventricular hypertrophy, sinus bradycardia, sinus arrhythmia, widening of QRS complex and right axis deviation between 91 and 180 degrees.[6]

It is noteworthy to state that electrocardiogram (ECG) is a key tool for the heart diseases diagnosis and evaluation of the cardiovascular events risk.[7] Consequently, it appears that the ECG parameters assessment in scuba divers can be practical for preventive and therapeutic measures, in order to reduce the cardiovascular events morbidity and mortality rate. Therefore, this study purpose was to investigate and analyze the electrocardiographic changes in scuba divers.

Materials and Methods

This quasi-experimental study was accomplished on saltwater scuba divers in the Persian Gulf, from October to December 2018. Divers were chosen from males with the age of between 19 and 50 years old, with 60 to 100 kg weight and also 160 and 195 cm height. All of them had scuba diving certification from the Navy of Islamic Republic of Iran. During the investigation period, all cases dived in the depth of 25 to 27 m; diving duration (including stopping in the depth) was 10 min and also 3 min was the duration of rising from the depth. Moreover, all diving cylinders were from the same types and contained 21% oxygen and 78% nitrogen combination. ECG was taken in each of the cases 10 min before, immediately and also by passing 60 min from diving. Exclusion criteria were as followings: trauma, marine animal bite, clinical diving disorders symptoms requiring treatment, tachyarrhythmia or

heart block before diving ECG, also beta-blockers, calcium channel blockers, antihypertensive or other drugs consumption affecting heart rate and rhythm and also underlying disorders background. All ECGs were interpreted by an emergency medicine specialist. Evaluation indicators were heart blocks, sinus arrhythmia and the heart rate changes, QT and PR intervals, QRS complex, ST segment and T wave.

This study was approved by the Ethical Committee of Guilan University of medical Sciences (IR.GUMS.REC.1396357) and informed consent for this study participation was obtained from the subjects.

This study results were expressed as mean±standard deviation or as number (percentage). Analysis was accomplished using Chi square and Friedman tests. All statistical analyses were done using SPSS software ver19. Significant level was set at 0.05.

Results

Included participants in this study were 37 males with the mean age of 35.7±4.27 years old and also with 25.7±1.97 kg/m2 body mass index (BMI). The water mean depth and temperature were 25.7±0.98 m and 15.4±1.25˚C, respectively. None of the cases had exclusion criteria. ECGs outcomes were listed and summarized in table 1. According to this table, there was a significant difference in the mean heart rate of cases between the investigations periods (P.V=0.005). In order to facilitate the resulting data analysis, the subjects were categorized in two age groups (<35 and >35 years old), BMI groups (<25 and >25 kg/m2), water depth groups (<25 and >25 m) and water temperature groups (14 to 15 and 16 to 17˚C). There was observed no significant change in the mean heart rate between cases of these two age groups, BMI groups, water temperature groups and depth groups, in the investigation time periods (P.V=0.94, 0.96, 0.17 and 0.37, respectively).

Table 1 displays a significant change in the mean QT interval of cases between the studied time periods (P.V=0.001, in both cases).

We found no significant difference in the mean QT interval between two age groups, BMI groups, water temperature groups and depth groups cases in the studied time periods (P.V=0.76, 0.29, 0.8 and 0.38, respectively).

With respect to the information of table 1, T wave change had significant difference between the studied time periods (P.V=0.001). Moreover, there was observed no significant difference according to T wave change between two age groups, BMI groups, water temperature groups and depth groups' cases in the studied time periods.

It is noteworthy to state that U wave, branch block, sinus arrhythmia and ST segment change indicated no significant difference during the studied time periods (P.V=0.13, 0.61, 0.53 and 0.13, respectively).

Discussion

All divers, whether beginner or professional, should be annually evaluated, in terms of their physical health, pulmonary function, electrocardiography, etc.[2] This research investigated the electrocardiographic changes in the scuba divers, before and after diving.

Totally, 37 scuba divers were evaluated in this study. The mean heart rate of the cases had immediately increased from 70 to 76 after diving and also decreased from 76 to 69 by passing 60 min from that; these changes were statistically significant (P.V=0.005). One of this study limitations was inability of measuring the divers heart rate in the water depth; However, the decrease in the heart rate is expected by increasing the pressure on the chest following increasing the depth, as same as Barbosa et al.[8] showed bradycardia in divers with increase in environmental pressure.

We found a significant change (P.V=0.001) in the cases mean QT interval, so that, the mean QT interval had immediately increased from 410 to 429 msec after diving and decreased from 429 to 409 msec by passing 60 min from that. We measured QT intervals using Bazett's formula ($QTc=QT/\sqrt{RR}$). Considering that, the longest QT intervals could be observed in the precordial leads V2 and V3, QT intervals were measured in these two leads. Ackerman et al.[9](1999) reported a form of long QT syndrome that could lead to sudden death in divers during swimming or going deep down to the water. Consequently, significant increase in the mean QT intervals of scuba divers has clinical value, and should be more comprehensively evaluated.

In this study, 2 (5%) cases had sinus arrhythmia before diving ECGs, which disappeared immediately and by passing 60 min from diving. In 3 (8%) cases, sinus arrhythmia was observed after diving ECGs and disappeared 60 min after diving. In 4 (10%) cases, sinus arrhythmia was seen before diving ECGs and disappeared immediately after diving, but then appeared 60 min after that. In 2 (5%) cases, sinus arrhythmia was appeared in ECGs, immediately and also by passing 60 min from diving. Overall, 19% of this study cases had sinus arrhythmia before diving, 11% immediately and 13% of them 60 min after diving, but in terms of that, no significant difference was found between the studied time periods.

Table 1. ECGs outcomes

	10 min before diving	Immediately after diving	60 min after diving	P.V
Pulse rate, mean (min-max)	70 (67-74)	76 (71-81)	69 (65-72)	0.005*
QT interval, mean (min-max)	410.4 (400-421)	429 (418-440)	409.5 (399.5-420)	0.001*
U wave, n (%)	14 (38%)	16 (43%)	12 (32%)	0.13
Branch block, n (%)	1 (2.7%)	2 (5.4%)	1 (2.7%)	0.61
Sinus arrhythmia, n (%)	7 (19%)	4 (11%)	5 (13%)	0.53
T wave change, n (%)	0	17 (46%)	7 (19%)	0.001*
ST segment change, n (%)	0	2 (5.4%)	0	0.13

*. Significant level was set at 0.05.

(P.V=0.53). In Mukerji et al.[6] study, 32% of divers reported sinus arrhythmia. The mechanism of sinus arrhythmia is increasing in the vagus tone; vagus tone increases with the depth of water increasing, so the formation of sinus arrhythmia is expected in divers.[10]

In this study, T wave changes were found as at least 2 mm increase in the T wave height in lead V3 and 1mm in lead II. Based on this study findings, in 2 (5%) cases, tall T waves appeared 60 min after diving ECGs. In 12 (32%) participants, tall T waves appeared immediately after diving ECGs, but it was also disappeared 60 min after that. In 5 (13%) participants, tall T waves was appeared in ECGs, immediately and 60 min after diving. generally, 46% of this study cases immediately, and 19% of them 60 min after diving had T wave changes, and these results were statistically significant. We know that T wave changes can be suggestive of repolarization instability and should be paid more attention to it and evaluated in divers.

With respect to this study results, in 1 (2%) case, right bundle branch block appeared in ECG immediately and 60 min after diving. In another (2%) case, left anterior superior fascicular block appeared in ECG immediately after diving, but it was disappeared 60 min after that. Totally, 2.7% of this study cases before, 5.4% immediately and 2.7% of them 60 min after diving had cardiac unifascicular blocks (left anterior superior fascicular block) and these findings were not statistically significant.

Additionally, 11 (37%) participants had U wave in all three ECGs. In 2 (5%) cases, U waves was appeared before and after diving ECGs, disappeared 60 min after diving. In 2 (5%) other cases, U waves was observed immediately after diving ECGs, disappeared 60 min after that. In 1 (2%) case, U wave was appeared before diving ECG, and disappeared immediately and also by passing 60 min from diving, and in another (2%) case, U wave was appeared in ECG, immediately and 60 min after diving. in general, 38, 43 and 32 percent of this study participants had U wave before, immediately and 60 min after diving ECGs, respectively, and this difference was not statistically significant. However, the U wave's incidence in divers was not evaluated in other researches.

None of our cases had ST segment changes before diving ECG, but these changes were found in 2 (5.4%) cases immediately after diving ECG and also was disappeared by passing 60 min from that.

It is noteworthy to state that QRS complexes and PR intervals had no significant changes between the investigations time periods (P.V=0.13).

On the other hand, none of this study participants had right axis deviation. However, in Mukerji et al.[6] study, 12% of cases had right axis deviation from 91 to 180 degree.

Due to professional divers screening in terms of weight and height by the Navy of Islamic Republic of Iran, the lack of significant difference between variables in terms of BMI was expected.

This study results demonstrated significant changes in pulse rate, QT intervals and T waves between studied time periods in scuba divers. Consequently, with respect to the clinical importance of long QT syndrome in arrhythmia and sudden death occurring and also by considering that the T wave changes can be suggestive of the repolarization instability, special attention to these changes in professional divers is required and highly recommended. Moreover, attention to the U waves formation and increased risk of developing torsade de points is another important point.

Finally, further investigations with more sample size and in pressure room with pH and blood potassium levels measuring, are recommended in order to obtain results that are more functional.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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