

# Unexpected Sudden Death Due to Recreational Swimming and Diving in Men in Croatia in a 14-Year Period

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## ABSTRACT

*The article deals with 17 sudden deaths which occurred during recreational swimming and diving in men in Croatia in a 14-year period: from January 1, 1998 to December 31, 2011. The sample is taken out from the total number of 61 sudden deaths in men during or immediately after sport or recreational exercise. Included are also sudden deaths of 8 foreigners spending holidays at the Croatian Adriatic Coast. In all of them forensic medicine autopsy was done. Thirteen males from Croatia died during recreational swimming. Three of them were aged 15–29 yrs: one had signs of hypertrophic cardiomyopathy, the second suffered from chronic myopericarditis with left ventricular aneurysm, and the third had cardiomegaly and blood alcohol level of 1.7‰. Five were aged 30–64 yrs: four of them have suffered from coronary atherosclerosis and left ventricular hypertrophy of 15–18–18–22 mm, and one with left ventricular hypertrophy drowned suddenly, probably because of malignant ventricular arrhythmia. The fifth suffered stroke and drowned. Five elderly men, aged 65–85 yrs, have suffered from coronary atherosclerosis, myocardial fibrosis or myocardial scars, and three of them had left ventricular hypertrophy of 19 mm. Four males died during recreational diving. One aged 26 yrs drowned, at autopsy he had left ventricular hypertrophy of 17 mm. Three males were middle-aged: two had coronary atherosclerosis, two of them had a severe degree of coronary atherosclerosis and one had coronary atherosclerosis of medium degree but with myocardial fibrosis and left ventricular hypertrophy of 18 mm. Seven male foreigners died, five of them during swimming: two aged 30–64 and two aged 65–85. They all have had coronary atherosclerosis: one of them had an acute myocardial infarction of the posterior wall, and one hypertrophic cardiomyopathy as well. One middle-aged and one elderly man died during diving, and both had an acute myocardial infarction of the posterior wall. One elderly foreign woman died during swimming, she had coronary atherosclerosis and a myocardial scar. In Croatia, death rate during both swimming and diving in men aged 15–29 years amounted to 0.63/1,000.000 ( $p=1.0000$ ); in those aged 30–64 it reached 0.56/1,000.000 ( $p=0.3698$ ), and in those aged 65–85 it was 1.41/1,000.000 ( $p=0.1849$ ). The death rate during swimming in men aged 15–29 amounted to 1.47/1,000.000 ( $p=0.9864$ ), in men aged 30–64 it reached 0.35/1,000.000 ( $p=0.2245$ ), and in those aged 65–85 it was 1.41/1,000.000 (the difference is significant,  $p=0.0472$ ). The death rate during diving in men aged 15–29 was 0.16/1,000.000, and in men aged 30–64 the observed rate was 0.21/1,000.000 ( $p=1.0000$ ).*

**Key words:** men, recreational swimming, recreational diving, drowning, sudden death

## Introduction

Physical exercise, if regular and controlled, has many beneficial effects, with very rare acute health complications. The most common reasons for sudden death dur-

ing recreational physical exercise in persons aged under 30 yrs are congenital heart diseases, while in middle-aged and elderly persons causes of death are arterial hy-

pertension and coronary heart disease, including sequels of cardio-metabolic syndrome<sup>1–16</sup>. Cardiovascular diseases are responsible for possible but rare complications in sports activities<sup>1–16</sup>, comprising also complications due to swimming or diving<sup>17–23</sup>.

The aim of this study is to analyze the prevalence and causes of sudden death in males due to recreational swimming and diving in Croatia.

### Sample and Methods

In a period of 14 years: from January 1, 1998 to December 31, 2011, the total number of 61 sudden and unexpected deaths during or immediately after sport or recreational exercises in males of all ages in Croatia were registered. Seventeen of them were men who died in summer due to recreational swimming and diving: eight in June, one in July, six in August and two in September. At that time no Croatian woman died due to such activities. Forensic autopsy was done in each presented case. The data are a part of a retrospective study, collected from the whole population consisting of 4,500,000 persons from the registry of the Forensic Medicine Services and the Public Health Registry of Croatia.

At the same time, eight foreigners died during recreational swimming: seven men and one woman.

The statistical difference was calculated by using the chi-square test and the Poisson rates.

### Results

In the mentioned period, 17 males in Croatia died during recreational swimming and diving: thirteen of them died during swimming and four during diving. Of those 13 persons who were engaged in recreational swimming, three were aged up to 29, five between 30 and 64, and five between 65–82 years. Among those engaged in diving, one was aged up to 30 and three were aged between 31 and 64.

In the same period eight foreigners died during swimming and diving, most of them at the Adriatic Coast: five were engaged in swimming: three aged 30–64 and two aged 65–85. Two were engaged in recreational diving: one was aged up to 29 and one between 30 and 64. One woman aged 82 swam in the sea and died. Table 1 presents forensic autopsy findings in men who died during recreational swimming and diving in Croatia in a 14-year period. These lethal events occurred in summer time, and in each case all applied reanimation efforts were unsuccessful.

Four men aged up to 29 years have been without any symptoms before the incident. The first, aged 29, swam in a swimming pool, suddenly collapsed and died. The autopsy finding revealed hypertrophic cardiomyopathy: the left ventricular wall reached 25 mm, with normal coronaries. The second, a school boy aged 18, swam and kept jumping into the sea, then suddenly collapsed and died. The autopsy finding showed chronic myopericarditis

**TABLE 1**  
THE FORENSIC AUTOPSY FINDINGS IN MEN WHO DIED DURING RECREATIONAL SWIMMING AND DIVING IN CROATIA IN A 14-YEAR PERIOD

		Age (years)		
		15–29	30–64	65–85
Swimming:				
CHD	Croatians	–	4	5
	Foreigners	–	2	2
Stroke	Croatians	–	1 (drowned)	–
	Foreigners	–	–	–
HCM	Croatians	2	–	–
	Foreigners	–	1	–
CMP(a)	Croatians	1	–	–
	Foreigners	–	–	–
Diving:				
CHD	Croatians	–	2	–
	Foreigners	–	1	1
LVH	Croatians	1	1	–
	Foreigners	–	–	–

Legend: CHD = coronary heart disease; HCM = hypertrophic cardiomyopathy; CMP(a) = chronic myopericarditis with left ventricular aneurysm; LVH = left ventricular hypertrophy

with left ventricular fibrosis and aneurysm of the anterior part of the left ventricle. The third, aged 19, swam in the sea and abruptly collapsed and died. The autopsy finding disclosed the whole heart enlargement of 450 g, pulmonary edema, bilateral pleural effusions, and serum alcohol level of 1.7‰ (2<sup>nd</sup> to 3<sup>rd</sup> degree of drunkenness). The fourth, aged 26, who was free-diving in the sea, suddenly disappeared under the surface, and was taken out a few hours later. The autopsy finding displayed left ventricular hypertrophy of 17 mm.

Eight middle-aged men from Croatia deceased: five due to swimming and three due to diving. The first, aged 57, obese, swam in a lake, collapsed and died. The autopsy finding showed obesity, coronary atherosclerosis, diffuse myocardial fibrosis and myocardial infiltration by

**TABLE 2**  
THE DEATH RATES IN MEN WHO DIED DURING SWIMMING AND DIVING IN CROATIA IN A 14-YEAR PERIOD

Age (years)	Died during swimming	Died during diving	Total
15–29	3 0.47/1,000.000 <sup>a</sup>	1 0.16/1,000.000 <sup>d</sup>	6 3999 134
30–64	5 0.35/1,000.000 <sup>b</sup>	3 0.21/1,000.000 <sup>e</sup>	14 262 906
65–85	5 1.41/1,000.000 <sup>c</sup>	0 –	3 549 448

a : b, p=0.9864; a : c, p=0.2245; b : c, p=0.0472; d : e, p=1.0000

fat tissue. The second, aged 33, swam in the sea, and suddenly drowned. The autopsy findings were typical for drowning, left ventricular hypertrophy of 15 mm, and punctate bleeding in the brain. The third, aged 52, swam in a river, all at once collapsed and died. The autopsy findings manifested enlarged total heart volume of 350 g, left ventricular hypertrophy of 18 mm, and coronary atherosclerosis with narrowing of all coronaries up to 70%. The fourth, aged 50, swam in a river and suddenly drowned. The autopsy finding exposed heart enlargement of 500 g, coronary atherosclerosis with stenotic coronaries and left ventricular hypertrophy of 22 mm. The fifth, aged 61, swam in the sea and suddenly drowned. The autopsy finding confirmed drowning because of stroke: hemorrhage in both cerebrum and cerebellum, and in the subarachnoid space, heart enlargement with left ventricular hypertrophy of 18 mm and diffuse coronary atherosclerosis. The sixth, aged 47, died due to recreational diving in the sea. The autopsy finding showed diffuse coronary atherosclerosis of a severe degree. The seventh, aged 60, died during recreationally diving in the sea. The autopsy finding registered diffuse coronary atherosclerosis of medium degree, myocardial fibrosis and left ventricular hypertrophy of 18 mm. The eighth, aged 60, was diving recreationally in the sea, and deceased under water. The autopsy finding showed severe diffuse coronary atherosclerosis.

Five elderly men from Croatia deceased during recreational swimming. The first, aged 69, swam in the sea, and suddenly collapsed and died. The autopsy finding showed diffuse coronary atherosclerosis of a moderate degree and myocardial scar of the front wall. The second, aged 82, swam in the sea, abruptly collapsed and died. The autopsy finding presented medium diffuse coronary atherosclerosis, diffuse myocardial fibrosis and left ventricular hypertrophy of 19 mm. The third, aged 68, swam in a swimming pool, all of a sudden collapsed and died. The autopsy findings demonstrated the whole heart enlargement, left ventricular hypertrophy of 19 mm, diffuse coronary atherosclerosis with narrowed left descending anterior coronary artery for more than 75%. The fourth, aged 82, swam in the sea, and suddenly collapsed and died. The autopsy finding was diffuse myocardial fibrosis, coronary atherosclerosis of medium to heavy degree with myocardial scar of the anterior wall of the left ventricle. The fifth, aged 74, swam in the sea, then suddenly collapsed and died. The autopsy finding displayed severe coronary atherosclerosis, myocardial scar of the posterior wall and left ventricular hypertrophy of 19 mm.

Out of 17 deceased persons from Croatia, 10 had left ventricular hypertrophy of 15–17–18–18–19–19–19–22–25 mm.

Death rate for both swimming and diving in Croatia, in men aged 15–29 years, reached 0.63/1,000.000 ( $p=1.0000$ ); in men aged 30–64 it was 0.56/1,000.000 ( $p=0.3698$ ), and in those aged 65–85 it amounted to 1.41/1,000.000 ( $p=0.1849$ ). The death rate during swimming in men aged 15–29 years reached 0.47/1,000.000 ( $p=0.9864$ ), in men aged 30–64 it amounted to 0.35/1,000.000 ( $p=$

0.2245), and in those aged 65–85 it was 1.41/1,000.000 (the difference is significant,  $p=0.0472$ ). The death rate during diving in men aged 15–29 reached 0.16/1,000.000, and in men aged 30–64 it was 0.21/1,000.000 ( $p=1.0000$ ).

In this period, five male foreigners visiting Croatia died due to swimming: three were middle-aged and two elderly, two died due to diving, and one elderly woman died when swimming. The first, aged 47, swam in the Adriatic Sea in June 2001, and suddenly sunk. The autopsy finding showed spongius pulmonary edema, coronary atherosclerosis of medium to severe degree. The second, aged 57, swam in the sea, and all at once collapsed and died. The autopsy finding showed generalized atherosclerosis, severe coronary atherosclerosis, acute myocardial infarction of the left ventricle posterior wall, and left ventricular hypertrophy of 15 mm. The third, aged 63, swam in the sea and suddenly collapsed and died. The autopsy finding revealed generalized atherosclerosis, whole heart enlargement of 580 g, diffuse myocardial fibrosis and left ventricular hypertrophy of 25 mm.

Two elderly male foreigners died due to recreational swimming. The first, aged 69, has suffered from arterial hypertension and died six months after cured stroke. He swam in the sea, then suddenly collapsed and died. The autopsy finding manifested generalized atherosclerosis of medium degree, the whole heart enlargement of 500 g, and left ventricular hypertrophy. The second, aged 74, swam recreationally in the sea, and suddenly collapsed and died. The autopsy findings were a spongius pulmonary edema typical for drowning, coronary atherosclerosis with narrowing less than 1 mm, a myocardial scar in the posterior wall, and left ventricular hypertrophy of 21 mm.

Two foreigners died due to diving. The first, aged 48, was diving recreationally in the sea. The autopsy finding showed the whole heart enlargement of 350 g, coronary atherosclerosis of medium to severe degree, acute myocardial infarction of the posterior wall, the right side liquidothorax of 120 ml, and left ventricular hypertrophy of 15 mm. The second, aged 77, was also recreationally diving in the sea. The autopsy finding exposed an acute myocardial infarction of the posterior wall, enlargement of the whole heart of 450 g, diffuse myocardial fibrosis, and left ventricular hypertrophy of 15 mm.

At that time one elderly female foreigner, aged 82, who has suffered from arterial hypertension, died during swimming. The autopsy finding showed spongius pulmonary edema, coronary atherosclerosis, myocardial scar of the posterior wall, and left ventricular hypertrophy of 22 mm.

## Discussion

Sudden death in healthy persons engaged in physical exercise is rare. When cardiovascular incidents do occur during exercise, the most frequent causes are congenital or acquired heart or vascular diseases. A great number of persons with coronary disease engage in physical exercise, and only a few experiences any discomfort. These data are supported by the analysis of the health-related

condition of the Croatian population: the so-called healthy persons of both genders aged 65–84 have six diagnoses on the range 0–17, including cardiovascular diseases<sup>1–13</sup>. Relative risk for cardiovascular complications seems to be higher in exertion than at rest. In young persons who died suddenly during physical exercise because of cardiac arrest – ventricular fibrillation, in about 6% of the cases the cause remains unexplained. Besides the fact that the heart is not trained for such efforts, the role of coronary spasm and reperfusion could be perhaps taken into account in the pathogenesis of sudden death. Many possibilities exist in defining an exertion-related sudden death. The time period needed for the cardiovascular system to return to resting steady state varies with many factors such as the type, intensity and duration of the activity, along with the health status and physical condition of the individual. Thus it is not easy to define exactly what is an exertion-related death, and especially sudden death caused by exercise.

There is an opinion that lethal events in swimming and diving mostly occur because of drowning but, in our experience, 13 people died due to swimming in 14 years. The primary reason for death due to swimming is an organic heart disease. One man aged 61 drowned in the sea because of stroke, and had a hemorrhage in both cerebrum and cerebellum and in the subarachnoid space as well, with heart enlargement, left ventricular hypertrophy and coronary heart disease. All other 12 died suddenly because of cardiovascular diseases: coronary heart disease in 10, and two younger ones because of hypertrophic cardiomyopathy, and one from chronic myopericarditis with heart aneurysm.

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Four of 17 Croatian victims died due to diving: one aged 26, had left ventricular hypertrophy, and others aged 47, 60 and 60 had coronary heart disease. Cardiovascular diseases may be, by some authors, responsible for a quarter of lethal events during diving<sup>17–19</sup>. In our data, however, cardiovascular diseases are responsible for all deaths due to swimming and diving.

What could be the main reasons for sudden death due to diving? According to some authors<sup>18,19</sup>, there is a vagal origin of sudden death. There are two vagal reflexes that might be responsible for lethal events: the diving reflex and the reflex dealing with the fear-induced central nervous system reaction<sup>18</sup>. The result of these stimulations could be diving bradycardia. In experiments when animals are threatened while diving, heart rate could be reduced to 2 to 6 beats *per* minute. Sudden vagal death could occur when the vagal cardiac nerves are stimulated synergically by two independent reflexes<sup>18</sup>. If one suffered from a heart disease, the consequence of vagal stimulation during diving could be much worse and lead to sudden death.

There are no written strategies for the reduction of those diving fatalities. That is why pre-diving medical check-up is necessary to avoid complications<sup>17</sup>.

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## IZNENADNA SMRT TIJEKOM REKREACIJSKOG PLIVANJA I RONJENJA U MUŠKARACA U HRVATSKOJ U 14-GODIŠNJEM RAZDOBLJU

### SAŽETAK

U članku je izneseno 17 naglih smrti u muškaraca za vrijeme rekreativnog plivanja ili ronjenja u Hrvatskoj u vremenu od 14 godina: od 1. siječnja 1998. do 31. prosinca 2011 g., od ukupno 61 muškarca preminulog za vrijeme ili neposredno nakon tjele vježbe, i u 7 muškaraca stranaca i jedne strankinje. U svih je provedena sudsko-medicinska obdukcija. Za vrijeme rekreativnog plivanja u Hrvatskoj naglo je umrlo 13 muškaraca. Trojica su bili u dobi 15–29 g.: jedan je imao hipertrofijsku kardiomiopatiju, drugi kronični mioperikarditis s aneurizmom lijeve klijetke, treći kardiomegaliju s koncentracijom etanola u krvi od 1.7%. Petorica su bila su dobi 30–64 g.: četvorica su imala koronarnu aterosklerozu i hipertrofiju lijeve klijetke 15–18–18–22 mm, a jedan od njih naglo se utopio, vjerojatno zbog maligne aritmije klijetki, dok se drugi utopio zbog razvoja apopleksije mozga. Pet ih je bilo tzv. starije dobi: 65–85 g., a imali su koronarnu aterosklerozu, fibrozu miokarda, ožiljke nakon preboljelog infarkta miokarda, a trojica su imala hipertrofiju lijeve klijetke od 19 mm. Četvorica su umrla za vrijeme rekreativnog ronjenja. Jedan u dobi od 26 g. imao je hipertrofiju lijeve klijetke od 17 mm, dok su trojica dobi 30–64 g. imali koronarnu aterosklerozu, jedan fibrozu miokarda i hipertrofiju lijeve klijetke od 18 mm. Sedam je stranaca umrlo, od toga petorica za vrijeme plivanja. Trojica su bila u dobi 30–64 g. a dvojica u dobi 65–85 g., od čega su četvorica imala koronarnu aterosklerozu, jedan akutni infarkt miokarda stražnje stijenke lijeve klijetke, a jedan hipertrofijsku kardiomiopatiju. Dvojica su umrla za vrijeme ronjenja: oba su imala akutni infarkt miokarda stražnje stijenke lijeve klijetke. Jedna žena starije dobi umrla je za vrijeme plivanja, imala je koronarnu aterosklerozu i ožiljak nakon preboljelog infarkta miokarda. Stopa smrti za vrijeme rekreativnog plivanja ili ronjenja, u 14-godišnjem razdoblju u Hrvatskoj u muškaraca dobi 15–29 g. iznosi 0,63/1.000.000 ( $p=1,0000$ ); u muškaraca dobi 30–64 g. iznosi 0,56/1.000.000 ( $p=0,3698$ ) i u onih dobi 65–85 g. iznosi 1,41/1.000.000 ( $p=0,1849$ ). Stopa smrti za vrijeme rekreativnog plivanja u muškaraca dobi 15–29 g. iznosi 0,47/1.000.000 ( $p=0,9864$ ), u muškaraca dobi 30–64 g. iznosi 0,35/1.000.000 ( $p=0,2245$ ), a u dobi 65–85 g. iznosi 1,41/1.000.000 (razlika je značajna:  $p=0,0472$ ). Stopa smrti za vrijeme ronjenja u muškaraca dobi 15–29 g. iznosi 0,16/1.000.000, a u muškaraca dobi 30–64 g. 0,21/1.000.000 ( $p=1,0000$ ).