

# Cardiovascular risk factors and cardiovascular risk assessment in professional divers

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## ABSTRACT

**Background:** The professional diver's activity implies body cardiovascular stress. Little data on cardiovascular risk factors is available. Some studies report a high prevalence of tobacco consumption. The purpose of this study is to investigate the cardiovascular risk factors of professional divers and calculate the predicted 5-year risk and the predicted 10-year risk of an acute coronary event.

**Materials and methods:** In one medical centre, data on dives and cardiovascular risk factors were analysed on Epidata<sup>®</sup> software, by Pearson  $\chi^2$  test or by Fisher's exact test, by analysis of variance test or by Kruskal-Wallis test, and by Spearman correlation coefficient. Cardiovascular risk scores at 5 and 10 years were calculated using SCORE.

**Results:** A total 200 professional divers were included. Of these, 31% were smokers or had stopped smoking for less than 3 years; 40% had an abnormal body mass index; 50% had raised total cholesterol levels; 11% had an advanced age; 6.5% had high blood pressure; 81% had at least one risk factor; 66% had an alterable risk factor; 25.5% had a 5-year risk greater than that of the general population of the same age; 2.5% had a high cardiovascular risk at 10 years; and 34% were at intermediate risk.

**Conclusions:** The majority of divers had at least one cardiovascular risk factor. Cardiovascular risk scores were lower than that of the general population. However, some of this population is at high risk. One third of the divers had an intermediate risk, which should lead to the consideration of conducting additional biological examinations to better assess their risk.

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**Key words:** risk factors, coronary disease/epidemiology, occupational diseases/epidemiology, diving, prevalence

## INTRODUCTION

The work of a professional diver submits the body to the stresses due to a hyperbaric environment, as well as physical work that the diver may have to do. From a cardiological point of view, the increase in stress is multifactorial [1–3], for example: accelera-

tion of heart rate by hypercapnia, impact of differences in airway pressure on thorax venous return, and impaired myocardial contractile function observed experimentally in animals. A study was carried out that showed the weight of cardiac work for professional divers according to the tasks performed [4].

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This explains why professional divers have special medical supervision, particularly for cardiac and pulmonary functions [5]. However, no studies to date have described the cardiovascular risk factors for this population. It is partially known that this population has modifiable risk factors, such as smoking [5] or, for some, physical inactivity [6]. The purpose of this study was to examine cardiovascular risk factors of professional divers and calculate the predicted 5-year risk and the predicted 10-year risk of an acute coronary event.

## MATERIALS AND METHODS

This is a descriptive study carried out in one medical centre for professional divers in France. The parameters were notified by the same doctor from the last visit's data. All divers were included. Socio-professional data (age, sex, type of activity, seniority in the profession, family and personal history) were noted, as well as profiles of dives (number of professional and recreational dives during the last year; average and maximum depths and average and maximum durations), lifestyle (smoking, physical activities), body mass index (BMI), electrocardiogram (ECG) at rest, cardiac stress testing (CST) with measurement of maximum oxygen consumption ( $VO_2$ max), and the results of biological tests (uric acid in blood, glucose, total cholesterol, triglycerides, proteinuria). Some divers also gave their levels of high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C).

From these data, the risk factors considered were the conventional risk factors: advanced age (> 55 years for men and > 65 for women), high blood pressure (HBP), non-severe hypercholesterolaemia (treated or untreated) (HCT), type 2 diabetes mellitus, being a current smoker or during the past 3 years [7]. Three major risk factors gave a high cardiovascular risk: type 2 diabetes associated with several other risk factors, severe HBP (systolic blood pressure – SBP  $\geq$  180 mm Hg and/or diastolic blood pressure – DBP  $\geq$  110 mm Hg), HCT  $\geq$  3.20 g/L [8].

The absolute cardiovascular risk at 5 years was calculated for people over 40 years of age using calculation software developed from SCORE and available online ([www.riskscore.org.uk](http://www.riskscore.org.uk)) [9]. For each of these divers, this risk score was compared with that of an individual in the general population of the same age. The absolute cardiovascular risk at 10 years was also calculated using the SCORE scale [10]. Low risk was equal to 0, intermediate risk was between 1 and 5, and high risk was more than 5%.

Data were entered and analysed on Epidata® software. The means and medians of the parameters were calculated and the extremes were determined. Comparisons of categorical variables were performed using the Pearson  $\chi^2$  test or Fisher's exact test (depending on the conditions of validity of the parametric tests). Comparisons of quantitative variables were performed using analysis of variance test or the Kruskal-Wallis test (depending on the conditions of validity of the parametric tests). Correlations were studied by the Spearman correlation coefficient. The divers were divided into four age groups (< 30, 30–39, 40–49 years, and > 50 years) and 5 classes according to BMI (normal BMI < 25, overweight if  $25 \leq$  BMI < 27, moderate obesity if  $27 \leq$  BMI < 30, major obesity if  $30 \leq$  BMI < 40, morbidly obese if BMI  $\geq$  40).

## RESULTS

A total of 200 divers were included in the study: 172 men and 28 women. The average age was 37.8 years (Table 1). In total 37 (18.5%) were less than 30 years old, 77 (38.5%) were between 30 and 40, 62 (31%) were between 40 and 50, and 24 (12%) were over 50 years old. The average age of women was lower than for men: 34.3 vs. 38.4 ( $p = 0.02$ ). The median annual number of dives, professional and leisure, was 69.6 and 45, respectively. 25% of the divers had conducted more than 100 dives per year; 93 (46.5%) divers did not practice recreational diving. Those who practiced recreational diving dived more than others: 76.9 vs. 61.9 annual dives ( $p = 0.03$ ). There was no significant difference between men and women according to the parameters of dives. The age and the seniority were not correlated in this population. Men had more seniority than women: average of 7 vs. 4.7 years ( $p = 0.02$ ). Thirty three (16.5%) used high-pressure hoses or vibrating tools; 36 (18%) cared for health of animals in aquariums; 25 (12.5%) fished for shellfish; 59 (29.5%) divers were monitoring coasts for scientific reasons; and 43 (21.5%) inspected ships, ports, or lighthouses.

Fourteen (7%) divers had a family history of myocardial infarction, 17 (8.5%) had a family history of dyslipidaemia, 17 (8.5%) had a history of diabetes, and 8 (4%) of HBP; 109 (54.5%) had a personal history of which 3 (1.5%) had a cardiac history, 4 (2%) HBP, 4 (2%), HCT, and 1 (0.5%) had diabetes. Thirty two (16%) had HBB during physical examination (Table 1). No divers had SBP or DBP greater than or equal to 180 and 90 mm Hg, respectively. There is no correlation between the presence of known or suspected hypertension with age, sex or smoking

**Table 1.** Age, seniority, dive profiles, tobacco, blood pressure, and maximal oxygen consumption (VO<sub>2</sub>max)

Items	Sous items	Averages	Medians (min-max)
Age [years]		37.8	38 (19-57)
Seniority [years]		6.7	4 (0-30)
Dives per a year		69.6	45 (0-450)
Duration of dives [min]	Averages	50.1	35 (1-180)
	Maximum	84.5	60 (2-480)
Depth of dives [m]	Averages	17.6	20 (3-50)
	Maximum	37.1	40 (6-70)
Tobacco	Cigarettes/day	14.1	15 (2-40)
	Pack per year	10.7	8 (1-40)
Blood pressure [mm Hg]	Resting systolic blood	123.4	120 (80-160)
	Resting diastolic blood	77.5	80 (50-120)
	Peak systolic	186.7	187 (80-240)
	Peak diastolic	85.4	80 (50-180)
VO <sub>2</sub> max [mL/kg/min]		40.5	39.0 (28-55)

habits. Among the divers, 58 (29%) smoked and 24 (12%) were former smokers, and 62 (31%) were smokers or had stopped smoking for less than 3 years. The average consumption of the smokers was 14.1 cigarettes per day (Table 1). The smokers dived more than the non-smokers: median 80 dives in the last year vs. 40 ( $p = 0.03$ ). Young people smoked more, 139 (69.5%) practiced regular physical activity: on average 3.9 hours per a week. Physical activity has no relation with other parameters.

One hundred twenty (60%) divers had a normal BMI, and 80 (40%) were either overweight or obese: 38 (18%) overweight, 30 (15%) in moderate obesity, 11 (5.5%) in major obesity, and 1 (0.5%) in morbid obesity. Men had more weight problems than women: 43.6% of men were at least overweight vs. 17.9% of women ( $p < 0.01$ ). Having a BMI over 25 was associated with age ( $p = 0.03$ ) but not by seniority.

Sixteen (8%) divers had abnormalities on resting ECG: 9 (4.5%) divers had a right bundle branch block, which was full for 1 of them, 6 (3.0%) divers had premature ventricular contractions (PVCs), and 1 (0.5%) diver had an arrhythmia. Four of 16 divers had a cardiovascular risk factor: 1 diver had a HBP and 3 divers smoked. Six divers had 2 risk factors and 1 diver had 3 risk factors: he smoked, was obese, and had increased triglycerides. Four (2%) divers showed an abnormality in CST: 2 (1%) divers had discomfort, 1 with loss of consciousness, 1 (0.5%) diver showed PVCs, and 1 (0.5%) diver had an ST segment elevation in V5 and V6. Three of these 4 divers had another

risk factor: 1 diver had an HBP, 1 diver had an HCT, and 1 diver was obese. The fourth diver had two risk factors: age and HCT. One of these 4 divers had an abnormality on resting ECG; moreover, he had HBP.

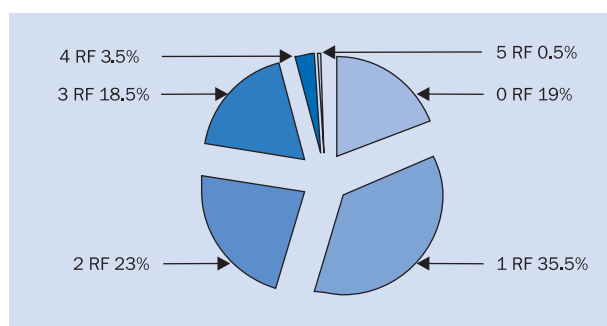
Fifty per cent of the divers had an HCT (Table 2). HDL-C and LDL-C were known to 39 and 34 divers, respectively. At least 14 (7%) divers had HDL-C greater than 0.60 g/L, and at least 1 (0.5%) diver had HDL-C less than 0.40 g/L. The proportion of divers with a total cholesterol increased with age, for each age class: 35.1%, 47.4%, 50.0%, and 83.3%, respectively ( $p < 0.01$ ). Thirteen (6.5%) divers had high blood glycaemia, but only 1 (0.5%) diver had diabetes.

Twenty two (11%) divers had advanced age (> 55 years for men and > 65 for women). Thirty seven (16.5%) divers had HBP. One (0.5%) diver had HDL less than 0.40 g/L. One (0.5%) diver had known diabetes and was being treated. Three (1.5%) divers had a suspicion of diabetes; 62 (31%) divers smoked or were weaned for less than 3 years. In total, 96 (48%) divers had at least one of these conventional risk factors. Taking into account heredity and HCT, 146 (73%) divers had at least one risk factor. Regarding BMI excess and abnormalities on the resting ECG and CST, 162 (81%) divers had at least one risk factor (Figure 1). In total, 132 (66%) divers had at least one modifiable risk factor, and 42 (21%) divers had at least a modifiable risk factor and did not take part in regular physical activity.

Two (1%) divers had one of three major risk factors: 1 (0.5%) diver had diabetes with other risk fac-

**Table 2.** Results of biological assessments of divers

Items	Sous-items	Averages	Medians (min-max)	Number of divers with high parameter
Uric acid	[ $\mu\text{mol/L}$ ]	316.4	315 (170-547)	2 (1.0%)
Glycaemia	[mmol/L]	5.79	5.1 (3.9-9.4)	13 (6.5%)
Total cholesterol	[mmol/L]	5.23	5.2 (3.04-8.62)	100 (50.0%)
	[g/L]	2.02	2.04 (0.80-3.34)	
HDL-cholesterol	[g/L] (39 askers)	0.57	0.52 (0.37-0.90)	
LDL-cholesterol	[g/L] (34 askers)	1.43	1.43 (0.83-1.94)	
Triglycerides	[mmol/L]	1.10	0.92 (0.38-3.96)	23 (11.5%)
	[g/L]	1.01	0.82 (0.33-8.00)	
Proteinuria	[g/L]	0.08	0.07 (0-0.68)	13 (6.5%)

**Figure 1.** Distribution of all risk factors (RF)

tors, and 1 (0.5%) diver had total cholesterol greater than 3.20 g/L.

The predicted 5-year risk of an acute coronary event risk was calculated for 91 divers. The average risk was 0.91%, with a median of 1% (0-4); 23 (25.5%) of these divers had a higher risk than the general population of the same age. Those who had a score higher than their age group smoked more than others and had more total cholesterol: 17 (77.3%) vs. 2 (2.9%) ( $p < 0.01$ ) and 18 (81.2%) vs. 39 (57.4%), respectively ( $p = 0.04$ ).

The predicted 10-year risk of an acute coronary was calculated for 115 divers. The average risk was 0.97%, with a median of 1% (0-7). 44 (22%) divers had a low risk, 68 (34%) divers had an intermediate risk, and 3 (1.5%) divers had a risk high. Considering the three major risk factors and risk score to 10 years, 5 (2.5%) divers had a high cardiovascular risk to 10 years.

## DISCUSSION

Ninety six (48%) divers had at least one conventional risk factor, and 162 (81%) divers had at least one risk factor when taking into account the tradi-

tional risk factors, HCT, and BMI. In fact, 80 (40%) divers were either overweight or obese, and 100 (50%) divers had an HCT; 132 (66%) divers had at least one alterable risk factor. The predicted 5-year risk of an acute coronary event in this population was generally lower than in the general population according to age and sex. But 25.5% of the divers had a higher risk, mainly because of smoking and HCT. At 10 years, 5 (2.5%) divers had a high cardiovascular risk.

This study concerned neither HDL-C nor LDL-C. Moreover, these assays are not part of the medical monitoring of divers in France [5]; it was impossible to recover these assays for the entire population. This could be an obstacle to the value of our calculation. Indeed, assessment by the Framingham score was not possible [11]. It is known that the risk assessment for this score is reliable [12]. Nevertheless, the population studied here was only French. Calculation of risk according to SCORE grid was therefore more suitable than the Framingham score [9]. The current method was therefore most appropriate. This study was important because the assessment of cardiovascular risk score allows detection of subjects at high risk, which is the priority in the context of primary prevention [13]. Meanwhile, the lack of data on LDL-C prevented evaluation of the rate of persons to be treated [14]. However, this is a descriptive study in the context of primary prevention, and the interest was to know what proportion of divers had cardiovascular risk factors, particularly alterable risk factors.

For the professional divers being medically followed [5], the fact that their risk is lower than the general population might be explained by the healthy worker effect. Indeed, the data in the general popu-

lation in primary prevention show a 10-year risk of 3% [15]. However, 25.5% of the divers had a 5-year risk greater than the general population and 2.5% of the divers were at high 10-year risk whereas professional diving submits the diver to an increase of cardiac work [4, 16-18]. So the question is whether medical monitoring is appropriate. A detailed study of cardiac work in the workplace would be interesting in order to better assess the risks for this population. Regarding divers at high risk, conducting a CST does not seem sufficient in light of the literature. Indeed, for this population, the positive predictive value of CST is low [19, 20]. The question then arises as to the relevance of other evaluation parameters, for example: assays of homocysteine, lipoprotein a [21].

Similarly, one can ask the same question for 67.5% of divers who showed no cardiovascular risk factor. Indeed, 20% of those with myocardial infarction had no risk factor [22]. But for these divers, the dosage of other cardiovascular risk markers would be outside the current recommendations and, probably, not relevant [13]. However, for 68 (34%) divers with an intermediate risk, a better assessment of cardiac risk might be considered [23], for example by performing an ultrasound pressure, including measuring the intima-media thickness of the carotid.

In comparison to data of the French population evaluated in the MONICA project (Multinational Monitoring of Trends and Determinants in Cardiovascular Disease) [24], divers in this study had less overweight or obesity (50% vs. 40%). This low prevalence of these problems could be related to physical activity and the awareness of such problems through their training. There were fewer hyperglycaemias: 20% vs. 13%. However, they smoked more: 21.5% vs. 31%. This high prevalence of smoking should be emphasised in this population. In addition to cardiovascular effects, the bronchial and pulmonary effects of tobacco are known in divers [5, 6].

The main risk factors are smoking, HCT, and, to a lesser extent, weight disorders; in other words, modifiable factors. The strategy of prevention is to intervene on modifiable risk factors, which therefore concerned 66% of the studied divers [25]. It therefore seems legitimate to improve primary prevention in this population on these points.

## CONCLUSIONS

Professional divers are particularly followed medically. However, 2.5% of them had a high 10-year risk of acute coronary event and 34% of them

had an intermediate 10-year risk of acute coronary event. This makes the question of measurement of other biomarkers of cardiovascular risk, particularly for those at high risk given the low positive predictive value of CST. Additionally, more accurate assessment of cardiac load during the professional diving activity should help to better assess the risk.

Moreover, two thirds had at least one alterable risk factor. Consequently, increased smoking cessation, better nutrition, and more physical activity should have a positive impact on cardiovascular risk in this population.

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