

Disabling diseases and disabilities in professional divers from the region of Murcia (Spain)

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ABSTRACT

Background: Professional diving is an activity that is carried out more and more frequently, due to the great professional opportunities it offers. It is a job with high responsibility and a lot of risk, involving low temperatures, adverse weather conditions, and high pressures, which requires the diver to be in optimal conditions. The general objective of this research work is to analyze disabling diseases and disabilities in professional divers in the Region of Murcia.

Material and methods: A descriptive and cross-sectional observational study, type of case series, has been carried out to analyze the causes and factors of the disabilities that occurred in 169 professional divers in the region of Murcia (Spain) from 2014 to 2020.

Results: The accumulated incidence of disability in seven years, with 39 cases, is 230.7 subjects per 1,000 divers, much higher than that of the rest of the maritime workers, which turns out to be 130.1/1000 in the same period of time. The average age is 33.7 ± 7.2 years, and the professional experience is 9.6 ± 6.1 years. Occupational diseases and work accidents were responsible for 15 (38.55%) cases. Otorhinolaryngologic (33.3%), musculoskeletal (25.6%), and psychiatric (10.2%) pathologies are the three most common causes.

Conclusions: Perfect physical condition, health and, especially, age in professional diving are a limitation, the latter being a risk indicator, so it is essential that the professional is in optimal physical condition and is aware of the limitations to carry out said professional activity, due to the great adversity it entails in being able to carry out it throughout one's entire active working life.

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Keywords: diving, accidents, barotrauma, disabilities, contraindications

INTRODUCTION

Professional diving is an activity that is carried out more and more frequently, due to the great professional opportunities it offers and the relative ease with which one can obtain the training that accredits it.

The work carried out under the sea, including the change in pressures to which the diver is subjected during daily work multiplied over months and years, can lead to multiple consequences, many of them disabling for the development of their profession. In addition to the repercussions for health, it entails a significant economic deterioration that

negatively affects the socioeconomic well-being of the family, forcing them to readjust to a change in professional activity.

However, most accidents are derived from non-compliance with regulations. "Professional divers in 2014 presented between 83.3 and 291.7 times more risk of having a fatal work accident than the average of the Spanish workforce" [1].

Cabo et al. [2] state that "The pathology associated with diving appears in more than 80% at the head and neck level. The most common injuries in diving accidents are disorders

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of the middle ear (46%), followed by disorders of the inner ear (18%), nose and paranasal sinuses (17%), external ear (8%), and decompression illness (8%)”.

Invasion by humans into the aquatic environment can be seen as a threat by marine species, which can have fatal consequences for the diver who enters the depths of the sea without any protection other than their suit.

For Ortiz [3], the most frequent are bites, trauma from the sting of species that inoculate poison, and electric shocks from fish.

Díaz [4] states that sinus and tympanic barotraumas are frequent in diving due to the complexity that these cavities present when it comes to the adaptability to the hyperbaric environment due to the presence of air inside “With an intact eardrum, the only route to balance pressures that the middle ear has is the Eustachian tube through the nasopharyngeal ostium. These ostia are normally closed and opened by the action of the tensor or elevator palate muscles, which occurs when swallowing”.

Because the opening of this cavity does not occur spontaneously and it is necessary to perform different maneuvers to force it — such as the well-known Valsalva maneuver — persistent blockages of the tubal ostium, congestion, edema, hemorrhage, and so on, may occur. “The pressure imbalance between the tympanic cavity and the nasopharyngeal cavity can lead to rupture of the tympanic membrane”.

For Carazo [1], decompression illness occurs to a lesser extent in experienced divers, and it is stated that only in 27% of cases do serious neurological symptoms appear, being more frequent in dives that require extra effort, in repeated dives, or deep dives in very low temperatures [1].

Regarding contraindications in diving, Barosa et al. [5] states that the pathologies that are not compatible with the practice of diving are those that pose a serious risk to diving, such as underlying pathologies that can worsen with diving, in addition to the basic motor alterations that are required to practice this practice.

When ear barotraumas are recurrent over time, which denotes the existence of poor tubal functionality, it must be considered that the diver has lost the ability to adapt to the hyperbaric environment and must be proposed for an evaluation to be declared incapable of practicing their profession [6].

In the case of an accident that has caused a decompressive illness, the cause of which is a gas embolism, serious or mild, depending on whether there has been neurologic involvement or simply limited to superficial dermatologic lesions or joint pain, and which has required specialized treatment in a hyperbaric chamber, it is very important to analyze the cause of the same, and it is often not identified once the diver’s non-compliance with the safety standards established in diving has been ruled out. As for divers who

have suffered from decompression illnesses of unknown and unforeseeable cause, considering the severity of their consequences, the permanent disability of the diver must be assessed [6].

GOALS

The general objective of this research work is to analyze disabling diseases and disabilities in professional divers in the Region of Murcia (Spain).

As specific objectives, the authors aim to determine the socio-occupational characteristics of divers who, due to presenting pathologies or physical defects, request or are proposed to be declared incapable of practicing their profession, and analyze the different pathologies causing the permanent disability process, and whether there is any known determining factor.

MATERIAL AND METHODS

STUDY DESIGN

An observational study has been carried out, with descriptive and transversal purposes — a type of case series, to analyze the causes and factors that exist around maritime workers who are dedicated to professional diving and who have resolved an administrative application process of disability for their profession, due to suffering from a common or professional illness, or the consequence of the consequences of having suffered an accident, work-related or due to other causes. Quantitative methodology has been used for the analysis of the variables that have been coded, and qualitative methodology has been used for the analysis of the texts of the documents analyzed.

The target population of the study was made up of maritime workers affiliated with the Spanish Special Social Security Regime for Sea Workers, in the Region of Murcia, managed by the state organization Instituto Social de la Marine (ISM).

The period of time studied is seven years, from 2014 to 2020. During this period, the population of active workers is quite uniform, taking as reference the number of affiliates at the end of November of each year analyzed, it ranges between 927 and 1,192 active workers, with an average of 1,114 workers in the period studied. The study population is made up of the 162 files resolved on permanent disability processes by the Provincial Directorate of the ISM of Cartagena, between 2014 and 2020, after the assessment of the resolution opinion of a medical court called the Disability Assessment Team (EVI, *Equipo de Valoración de la Incapacidad*) of the National Institute of Social Security, once the medical reports of the seafarers who initiated the administrative process in order to obtain a disability for the exercise of professional activity as seafarers have been analyzed and assessed.

The only inclusion criterion is that the resolved permanent disability file was for professional divers; thus, the sample studied was 39 documents during the aforementioned period. Documents belonging to the same subject, generated by a review or new assessment of the EVI, as a consequence of a claim or other administrative reasons, were excluded, thus ensuring a single file per subject.

In the document where the EVI presents its evaluation opinion of the disability process initiated, there is a free text section where it develops, in abbreviated form, the clinical picture responsible for the disability process and the organic and functional limitations of the worker, always considering the tasks typical of the diving profession, in the which they have relied on to make their proposed opinion. After reading the text, the authors have considered it of interest to code pathologies by groups or systems. Multiple causative pathologies are common; in these cases, the most relevant ones were chosen as the cause of the disability.

For the analysis of results, descriptive statistical techniques have been used, values of the frequencies of the categories of the qualitative variables and the values of the arithmetic mean, standard deviation, range of values, and values of the percentiles when the variable to be analyzed was quantitative. To test hypotheses, since these are very small samples, non-parametric statistics, the Mann-Whitney U, and the Kruskal-Wallis test have been used to analyze the distribution of a quantitative – qualitative variables. Statistical significance was accepted for a value of $p < 0.05$.

RESULTS

The total number of proposed reports of permanent disability from the EVI, of the National Social Security Institute, to maritime workers, in the Region of Murcia, is 162 cases, in the referred period, of which 39 belong to professional divers.

The group of active maritime workers in the Region of Murcia is made up of 1,114 subjects, which represents a cumulative incidence in the seven years reviewed of 145.4 cases of disability per 1,000 workers.

Analyzing separately the accumulated incidence of the group of active professional divers, made up of 169, and the 945 that make up the rest of the maritime workers, it was found that the incidence of proposed disability ruling in divers is 230.7 cases for each 1,000 divers in the seven years analyzed, an incidence much higher than that of the rest, which turns out to be 130.1 cases per 1,000 in the same period.

The overall average age obtained is 33.7 ± 7.2 years, with a range of values between 25 and 53 years. The median value is 36.0 years, with the 75th percentile corresponding to

the value of 41 years and the 25th percentile corresponding to the value of 31 years.

Regarding the reference to the years of professional activity as divers, an average value of 9.6 ± 6.1 years was obtained. The percentile value of 50 is 8 years of work as a diver, 14 years is the 75th percentile, and 4 years is the 25th percentile. The range of values is between 1 and 24 years.

Pathologies and factors causing disability:

- Otorhinolaryngologic (ENT) – 13 (33.3%) cases, which is the most frequent group:
 - 10 cases of chronic rhinosinusitis, resulting in the most frequent pathology within the ENT group, 76.9%, and representing 25.6% of the total disability processes in the study,
 - 2 cases of chronic otitis media, as consequences of barotrauma, with involvement of the middle ear, requiring surgical intervention to repair the eardrum,
 - 1 case due to inner ear pathology, with vertiginous symptoms.
- Musculoskeletal – 10 (25.6%) of the cases, occupying second place, of which 7 (70%) were due to a common illness or non-work accident and 3 (30%) were due to a work-related accident. The pathologies described:
 - 4 of the cases in this group were as a consequence of disc disease at the cervical and lumbar spine level,
 - 5 cases were related to consequences of trauma, caused by a work or traffic accident, 3 cases in the lower extremity, and 2 cases in the shoulder,
 - 1 refers to the Arnold Chiari malformation, diagnosed after the study of severe headaches and dizziness during diving, asymptomatic when not in a hyperbaric environment.
- Psychiatric – 4 (10.2%) cases, described as:
 - 2 anxious-depressive disorder, one associated with adverse life circumstances,
 - 1 somatoform disorder, presents various symptoms not explained by the existence of a conclusive organic lesion,
 - 1 adjustment disorder, stressful situation with significant problems at work.
- Neurologic – 3 (7.7%) cases, described:
 - the 3 cases are recorded as an epileptic disease, one as a temporary irritative outbreak, the second as clonus in the right hemibody associated with language disorders, and a third as a tonic-clonic seizure due to frontal cortical dysplasia.
- Decompression illness – 3 (7.7%), all of them presented accidentally as type 2 decompression illness, with neurological involvement:
 - 1 case that leaves as a sequel a right vestibular dysfunction that produces vertiginous symptoms,

- 1 case, which produces important neurological alterations and evolves without leaving sequelae, but which is recurrent, two cases in a short period,
- 1 case, which left a facial sensory alteration as a sequel.
- Cardiovascular disease – 2 (5.1%) cases:
 - 1 patent foramen ovale, diagnosed after a study for syncope during a dive,
 - 1 case of congenital malformation of the left internal carotid artery, causing a transient ischemic attack.
- Dermatologic – 1 (2.6%) case:
 - 1 for chronic histiocytic folliculitis due to the pressure of the neoprene suit.
- Endocrine – 1 (2.6%) case:
 - 1 Diabetes 1, in a 32-year-old, asymptomatic diver, diagnosed in a professional fitness medical examination.
- Urological – 1 (2.6%) case:
 - 1 neurogenic bladder with hypotonia, the diver needs to continually perform self-catheterization to empty the bladder.
- Pulmonologic – 1 (2.6%) case:
 - 1 extrinsic bronchial asthma.

Occupational diseases and work accidents are responsible for 15 (38.55%) cases.

Of the cases of disability, 8 (20.5%) are as a result of the previous existence of allergic processes, such as the case grouped in pulmonology, 1 (2.6%) diagnosed as extrinsic bronchial asthma. There is also an allergic cause in 1 (2.6%) case classified as a dermatologic process, due to an allergy to a certain chemical compound in the neoprene with which diving suits are made. As a consequence of various allergic processes, there are 6 cases of rhinosinusitis, which represent 15.4% of the total sample studied, 60% of the rhinosinusitis described, and 46.2% of the total ENT cases.

Table 1 shows the analysis of age and professional experience, with the differences not being statistically significant in any case found, depending on the independent variables analyzed. However, it can be highlighted that the 3 cases of professional divers in hydraulic works are much older, 44.3 ± 10.2 years, than the fish farm divers, 36.1 ± 6.7 years, $p = 0.140$.

In Table 2, the age and professional experience in relation to the group of pathologies analyzed and involved in the permanent disability process is described. It can be highlighted that the average ages of the grouped pathologies all exceed 30 years, but none of them reach 40 years, except for the only case belonging to urology, with 45 years. If one analyzes the minimum and maximum age ranges, it can be observed that in all groups, there are divers for whom a disability file has been initiated at very young ages, 30 years or less.

If one analyzes the experience of the worker as a professional diver (Tab. 2), in all pathology groups, except musculoskeletal diseases, and isolated cases of urology and endocrinology, the average professional experience is below 10 years, highlighting how the value of the minimum experience range in all cases is less than or equal to 3 years, with the maximum value of 24 years of experience corresponding to the group of musculoskeletal pathologies in most of the pathological groups, the maximum professional experience of divers with a disability record does not reach 20 years (Tab. 2).

DISCUSSION

The disability for professional diving is very considerable, with a cumulative incidence of 230.7/1000 cases in seven years, almost double that of the rest of the group of maritime

Table 1. Age and seniority and their relationship with activity, contingency, and disability

	Age		Antiquity	
	M $\pm$ SD	Average range	M $\pm$ SD	Average range
Activity				
Fish husbandry	36.1 $\pm$ 6.7	19.1	9.3 $\pm$ 6.1	19.5
Underwater construction	44.3 $\pm$ 10.2	29.6	12.6 $\pm$ 6.5	25.8
	p = 0.140		p = 0.374	
Contingency				
Common disease	37.1 $\pm$ 6.7	20.8	10.2 $\pm$ 6.5	20.9
Professional illness	35.2 $\pm$ 9.0	16.7	7.8 $\pm$ 3.4	17.3
Work accident	36.6 $\pm$ 8.2	19.5	9.0 $\pm$ 6.3	19.0
	p = 0.749		p = 0.765	
Disability proposal				
Yes	37.4 $\pm$ 8.2	20.7	9.7 $\pm$ 6.8	19.9
No	35.3 $\pm$ 4.6	18.4	9.3 $\pm$ 4.4	20.0
	p = 0.549		p = 0.988	

M – mean, p – statistical significance, SD – standard deviation

Table 2. Age and seniority and their relationship with the pathologies of the opinion

Pathologies	Age		Seniority	
	M ± SD	Range min–max	M ± SD	Range min–max
ENT (n = 13)	36.6 ± 6.6	28–47	9.0 ± 4.3	
Osteomuscular (n = 11)	38.4 ± 7.4	28–53	11.6 ± 6.9	3–18
Psychiatry (n = 4)	34.5 ± 4.2	29–39	8.5 ± 5.0	2–24
Neurology (n = 3)	33.3 ± 7.6	30–51	3.3 ± 2.5	
Cardiology (n = 2)	32.5 ± 10.6	25–40	8.5 ± 10.6	2–13
Decompression disease (n = 3)	37.3 ± 11.8	30–51	9.3 ± 8.0	1–17
Allergies (n = 8)	38.6 ± 6.3		9.6 ± 6.0	1–16
Pulmonology (n = 1)	30	30–47	3	1–16
Urology (n = 1)	45		20	
Endocrinology (n = 1)	33		13	3–18

ENT – otorhinolaryngological, M – mean, SD – standard deviation

workers in the same period of time, 130.1/1000 cases. If one considers incidence a measure of risk, one can interpret that this high risk of suffering disability is a consequence of the hardness of the work and, on the other hand, the requirement that divers have a perfect state of health to guarantee their activity safely [7].

Ciudad-Valls [8] stated that the Autonomous Community of Murcia is the second community with the highest accident rate in Spain for divers.

The age difference in the present study is striking, an average of 33.7 years, compared to the age of the study carried out by Balanza [9], whose average age was 50.6 years in the disabled maritime workers in the study, where there was no population of professional divers; they were all merchant sailors and fishermen.

The ISM [6] considers age as an aspect of special consideration in the Protocol for assessing fitness and health monitoring in professional diving due to the hardness of the physical work and the unfavorable conditions that this practice entails. Furthermore, it is interesting to highlight the short professional experience of divers in the professional activity, with only 9.6 years on average. Age and professional experience are associated with the disability processes of this group of workers; for health reasons, they are disabled at a very young age and with little experience.

Age seems to be one of the most important risks for the development of pathologies associated with diving, with type 2 Decompression Illness being more common after the age of 35 [8]. The subject of the present study, who suffered from decompression illness of unknown cause, was over 50 years of age, granting him a permanent disability as a preventive measure, as it was a recurring accident with no known cause, considering the extreme severity of the consequences or even a result of death to which he was exposed.

Diseases caused by otorhinolaryngological (ENT) pathologies are the most numerous, representing 33.3% of work disability. Cabo et al. [2] already stated that middle ear pathology was the most common, however, in the present results rhinosinusitis appears as the main cause, but it must be considered that all divers with chronic rhinosinusitis suffer from tubal dysfunction that in turn, they cause middle ear pathology, and less frequently the inner ear, the last link in a chain that leads to the inability to practice diving. The diver is not disabled by suffering from chronic rhinitis but by its consequences. The physiological changes in the ear of divers after immersion have been described in the literature by Boyle Mariotte's Law on the variation of pressure in the middle ear, being a cavity with gas, therefore, it is common to find a thickening of the eardrum, this being matte, dull and without shine [10] which although they are not disabling alterations, they are a reflection of the consequences that changes in pressure to those to which divers are exposed and which harmfully affects the structures of the ear and mucous membranes of the upper airways [10].

In second place, musculoskeletal diseases occupy 25.6%, a frequency somewhat lower than that of studies taken as a reference in the maritime fishing sector. Musculoskeletal processes occupy first place, 31.8% in the study by Balanza [9] and 29.1% in that of Benítez and Táuriz [11].

The cause of the mechanisms that produce the accumulation of nitrogen bubbles in the diaphysis of long bones, such as the femur, tibia, and humerus, and in the joint areas of these bones, causing aseptic necrotic areas, is unknown. The symptoms they present can be confused with arthritis or trauma, and in their early stages, they are asymptomatic, but they can become disabling injuries, even leading to the need for orthopedic prostheses. In the seven years reviewed of the disability process in divers, the authors have not found any case of necrotic bone pathology.

CONCLUSIONS

The incidence of disabilities due to pathologies derived from diving activity is increasing, and it is alarming to see their appearance in increasingly younger subjects with little professional experience. It is necessary to guarantee, through updated laws, the safety conditions of the professional divers with more precise indications regarding health surveillance and medical examinations, with the unification of criteria at the national level.

The disrepair of physical health and — especially — age in professional diving are limiting factors, the latter being an indicator of risk. It is essential that the professional is in optimal physical condition and is aware of the limitations in carrying out professional activities, due to the great adversities they may face if they are to carry them out throughout their entire active working life.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement: Authors declare under their responsibility that the data has been collected and is stored in a secure place. The data is available on reasonable request.

Ethics statement: Authors declare under their responsibility that the data collected has been treated with total confidentiality and under the appropriate ethical code.

Author contributions: All authors contributed to conception, design, execution, interpretation of the data and writing the manuscript.

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