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Osteomuscular Diseases in Maritime Workers in the Region of Murcia (Spain).

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ABSTRACT

Introduction: Seafarers are a group that is particularly vulnerable to musculoskeletal disorders due to the specific characteristics of their work and the adverse conditions in which they carry out their professional activities. Objective: To describe the musculoskeletal problems arising from professional activities in seafarers in the Region of Murcia (Spain). Methodology: This is an observational analytical case-control study in which professional divers were defined as the exposed group (cases) and fishermen as the unexposed group or controls. Results: in the analysis of the occupational pathologies suffered by these two groups of maritime workers, we observed that 152 (50.8%) responded in the survey that they had suffered joint problems in the last year in some of the eight groups of musculoskeletal areas analysed, with this being more frequent in divers than in fishermen, 59 (57.8%) and 93 (47.2%) respectively. Only 33 subjects reported having suffered work disability in the last year, representing 11% of the total sample and 21.7% of those who reported having suffered musculoskeletal pathology. Analysing these work incapacities by activity, it is more frequent in divers, 14 (13.7%), compared to fishermen, who present 19 (9.6%) cases, p=0.286. Conclusions: Exposure to professional diving is significantly associated with a higher probability of presenting musculoskel pathologies compared to other maritime workers, namely fishermen.

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1. Introduction.

If we consider the data provided by the World Health Organization Musculoskeletal [1], disorders represent one of the main health problems due to their high prevalence and chronic progression, affecting workers' quality of life and work capacity. This pathology can affect muscles, bones, joints, tendons and ligaments, and is mainly associated with prolonged exposure to biomechanical and ergonomic risk factors present in various work environments, such as maritime work to Bernard 1997 [2]. In this context, maritime workers represent a particularly vulnerable group due to the specific characteristics of their work and the adverse conditions in which they carry out their professional activities.

Among maritime professions [3] professional fishing has been recognised as a high-risk activity, with a high prevalence of musculoskeletal disorders, attributed to it being a physically demanding activity involving the manual handling of heavy loads, repetitive movements, forced and sustained postures, constant exposure to vibrations, working on unstable surfaces and in extreme weather conditions, all of which significantly increase the risk of developing musculoskeletal disorders to Aasjord et al 2013 [4]. Added to these factors are long working hours, insufficient breaks and ergonomic limitations inherent in the design of vessels, which favour the onset of both acute and chronic musculoskeletal injuries.Jensen et al 2008 [5].

Numerous studies such as Buchholz et al 2017 [6] have pointed out that the anatomical regions most frequently affected in maritime workers are the spine, especially the lumbar and cervical regions, followed by the shoulders and upper extremi-

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ties. Punnet and Wegman claim that the most common clinical manifestations include low back pain, neck pain, tendinopathies, and bursitis, which can progress to persistent pain, functional limitation, and, work disability [7]. These conditions not only impact the individual health of workers to European Agency for Safety and Heallth and Work 2019, but also have significant economic and social consequences, such as increased absenteeism, decreased productivity, and increased occupational health costs [8].

From a comprehensive occupational health perspective, it is also necessary to consider the influence of organisational and psychosocial factors, such as pressure to be productive, job instability, staff shortages and limited access to health services, which can contribute to the persistence and worsening of musculoskeletal disorders to Bongers & Kremer 2002 [9]. In many cases, Torner & Pousette claims that maritime workers continue to perform their duties despite pain, which increases the risk of irreversible injuries and occupational accidents [10].

Diverses studies such as of Flatmo et al, Johannessen et al and Gronning et al claims that professional diving shares some of the general conditions of maritime work, but also incorporates specific risk factors derived from underwater work in a hyperbaric environment. Among professional divers in Norway, musculoskeletal disorders are highly associated with sick leave. A study that included a randomly selected cohort found that highly demanding jobs, neck flexion, and physical exertion appear to be the most important predictors of neck/shoulder pain [11,12,13].

Several studies have described the existence of musculoskeletal disorders in professional divers. A study conducted in the United Kingdom found that divers reported more musculoskeletal disorders than other offshore workers who did not dive [11,14]. In another study of Norwegian maritime workers, the risk of musculoskeletal discomfort, strain injuries and joint pain was significantly higher among divers working in the construction sector than among divers not working in this sector, and among divers who had previously experienced decompression sickness (DCS). Similarly, a higher risk was observed among divers who performed construction, inspection, pipe laying, blasting and welding work than in other physically demanding jobs.

2. Objetives.

The general objective of the study is to describe the musculoskeletal problems arising from professional activity in maritime workers in the Region of Murcia (Spain).

The specific objectives are to analyse whether there is a relationship between musculoskeletal disorders and professional diving, comparing divers with fishermen as a reference group, and evaluating the influence of other variables such as age, length of service, obesity, and regular physical exercise as a healthy habit.

3. Material and Methods.

This is an observational analytical case-control study in which professional divers were defined as the exposed group (cases) and fishermen as the unexposed group or controls. The information was obtained at a single point in time through structured data collection. There was no follow-up of the subjects and no temporality was established between the variables, so risk cannot be measured, but the magnitude of association can be measured using the odds ratio (OR) statistic.

The target population consisted of maritime workers in the Region of Murcia, comprising 169 professional divers and 460 fishermen. The sample size was calculated for a case-control study, with an approximate ratio of 2:1, 95% confidence, 80% power, and a minimum clinically relevant OR of 2.0. To estimate the expected proportion of musculoskeletal pathology in the control group, data available in the literature and clinical records of sea workers were used, which describe a frequency of 40%. With the above data, the required size in the calculation was 101 cases and 192 controls. The sampling used was non-random, consecutive, finally reaching 299 participants, 102 exposed (divers) and 197 controls (fishermen), which ensures sufficient power to detect associations of moderate magnitude.

Participants were included in the sample on the day they attended the Maritime Health Service to undergo the mandatory medical examination to be able to work in any maritime activity between 2021 and 2022. Data collection forms were completed for as long as necessary until the estimated sample size was reached. The following exclusion criteria were established: being unemployed, foreign workers with poor communication skills due to language barriers, having recently suffered musculoskeletal trauma due to a work or domestic accident, and refusing to participate in the study.

The information was collected on a form that was self - completed and provided by the worker when they went for their medical examination. The dependent variable used was the presence of musculoskeletal pathology in the 12 months prior to the medical examination in the different joint areas (shoulders, elbows, hands, cervical area, thoracolumbar area, hips, knees, and feet), with a positive response when the joint symptoms and clinical signs were persistent or recurrent over time. The main independent variable was occupational activity (diver = exposed; fisherman = not exposed). Other independent adjustment variables: age (years), length of service (years), Body Mass Index (BMI) ($^{kg/m^2}$), physical exercise (ordinal variable with a value from 1 to 4, where 4 is rare or never and 1 is more than three times a week), smoking habit.

For statistical analysis, data from each patient was collected in an Excel database and then exported to IBM SPSS Statistics version 22 for processing. For descriptive analysis of qualitative variables, absolute and relative frequencies of categories were calculated. Quantitative variables were presented with mean values, standard deviations, and 95% confidence intervals. The need for normality analysis of quantitative values was not considered, as both samples contained a large number of elements. In the comparative analysis between groups, the chi-square statistical test was used to cross-reference qualitative variables, and the odds ratio (OR) with its 95% confidence intervals was also presented to measure the magnitude of risk. The association between qualitative and quantitative variables was assessed using Student's t-test ( ). For exploratory

purposes, a multivariate binary logistic regression analysis was performed, applying the enter method and introducing all the independent variables of the study into the regression model, with the aim of controlling for confounding factors and measuring the association with the adjusted odds ratio with its 95% confidence interval.

In hypothesis testing using statistical methods, the null hypothesis is rejected and the alternative hypothesis is accepted for values of $p<0.05$.

The study protocol was conducted in compliance with the Declaration of Helsinki.

Informed consent: Written informed consent was not required, as participants provided verbal consent at the time of undergoing the clinical procedures necessary for their work. Participation was entirely voluntary; those who did not wish to participate clearly stated so and were excluded from the study. This wording is consistent with the use of verbal consent when written consent is not feasible or appropriate, while preserving voluntariness, anonymity and the right to decline.

4. Results.

The sample for this study consisted of 299 subjects working at sea, of whom 197 (65.9%) were fishermen and 102 (34.1%) were divers. The overall mean age was 44.03 ± 10.00 years (95% CI 42.19 - 45.17), with fishermen being older, at 46.54 ± 9.72 years, compared to 39.18 ± 8.69 in the group of divers, $p<0.001$. In terms of length of service, the sample studied had an average of 20.06 ± 12.25 years (95% CI 18.67–21.46), with fishermen having a higher average of 24.06 ± 11.81 years, compared to divers with only 12.34 ± 8.98 years, $p<0.001$.

Table 1: Obesity, smoking and physical activity according to occupation.

	Fishing n=197	Diving n=102	Total N=299	P
Obesity BMI				
<30	132 (62.4%)	86 (84.3%)	209 (69.9%)	<0.001
≥30	74 (37.6%)	16 (15.7%)	90 (30.1%)	
Smoking				
Yes	104 (52.8%)	32 (31.4%)	136 (45.5%)	<0.001
No	58 (29.4%)	44 (43.1%)	102 (34.1%)	
Ex-smoker	35 (17.8%)	28 (25.5%)	61 (20.4%)	
Physical activity				
>3 times/week	36 (18.3%)	42 (41.2%)	78 (26.1%)	<0.001
1-3 times/week	38 (19.3%)	41 (40.2%)	79 (26.4%)	
Once a month	58 (29.4%)	12 (11.8%)	70 (23.4%)	
Rarely or never	65 (33.0%)	7 (6.8%)	72 (24.1%)	

Source: Authors.

In the analysis of variables related to habits and constitution, the mean BMI value of the sea workers who participated in the study was 28.24 ± 5.15 (95% CI 27.66–28.83), with very significant differences between the groups, $p<0.001$, 29.11 ± 5.61 for fishermen and 26.57 ± 3.47 for divers. Table 1 shows the differences found in terms of obesity, smoking and physical exercise, highlighting fishermen as the occupational group with the highest frequency of smokers and individuals with any degree of obesity, and the group that performs the least physical exercise, with the difference being statistically significant in all cases (Table 1).

In the analysis of occupational pathologies suffered by these two groups of maritime workers, 152 (50.8%) responded in the survey that they had suffered joint problems in the last year in some of the eight groups of musculoskeletal areas analysed, being more frequent in divers than in fishermen, 59 (57.8%) and 93 (47.2%) respectively, which is close to statistical significance, p=0.081. Only 33 subjects reported having suffered work disability in the last year, representing 11% of the total sample and 21.7% of those who reported having suffered musculoskeletal disorders. Analysing these work incapacities by activity, it is more common in divers, 14 (13.7%), compared to fishermen, who present 19 (9.6%) cases, p=0.286.

Table 2 shows the frequency distribution by joint area. In the overall analysis, we highlight the highest frequency of lumbar pathology with 91 (30.4%) cases, followed by knees with 48 (16.1%), with the cervical region and shoulders in third place with the same frequency, 46 (15.4%) cases.

Table 2: Frequency of musculoskeletal pathologies by joint area and occupational activity.

		Fishing n=197	Diving n=102	Total N=299	OR (95% CI) P
Cervical					
	Yes	23 (11.7%)	23 (22.5%)	46 (15.4%)	2.20 (1.16 - 4.16) 0.013
	No	174 (88.3%)	79 (77.5%)	253 (84.6%)	
Shoulders					
	Yes	24 (12.2%)	22 (21.6%)	46 (15.4%)	1.98 (1.49 – 3.74) 0.033
	No	173 (87.8%)	80 (78.4%)	253 (84.6%)	
Elbows					
	Yes	9 (4.6%)	17 (16.7%)	26 (8.7%)	4.1 (1.79 – 9.77) <0.001
	No	188 (95.4%)	85 (83.3%)	273 (91.3%)	
Hands					
	Yes	13 (6.6%)	14 (13.7%)	27 (9.0%)	2.25 (1.01 – 4.99) 0.042
	No	184 (93.4%)	88 (86.3%)	272 (91.0%)	
R. Lumbar spine					
	Yes	50 (25.4%)	41 (40.2%)	91 (30.4%)	1.97 (1.18 – 3.28) 0.008
	No	147 (74.6%)	61 (59.8%)	208 (69.6%)	
Hips					
	Yes	10 (5.1%)	4 (3.9%)	14 (4.7%)	0.76 (0.23 – 2.49) 0.654
	No	187 (94.9%)	98 (96.1%)	285 (95.3%)	
Knees					
	Yes	25 (12.7%)	23 (22.5%)	48 (16.1%)	2.00 (1.07 – 3.74) 0.028
	No	172 (87.3%)	79 (77.5%)	251 (83.9%)	
Ankles					
	Yes	11 (5.6%)	7 (6.9%)	18 (6.0%)	1.24 (0.46 – 3.31) 0.659
	No	186 (94.4%)	95 (93.1%)	281 (94.0%)	

Source: Authors.

If we analyse the different musculoskeletal pathologies by area and activity, measuring the risk of suffering from them, Table 2 shows that divers are at greater risk of suffering from

all pathologies except those affecting the hips. We highlight the high frequency in the thoracolumbar area, where divers are twice as likely to suffer from these pathologies, OR= 1.97 (95% CI 1.18 – 3.28), p= 0.008. The same risk applies to the knees, with 22.5% of divers reporting clinical symptoms and signs compared to 12.7% of fishermen, OR= 2.00 (95% CI 1.07 – 3.74), p= 0.028.

Considering the bivariate analysis, the difference in risk of suffering musculoskeletal pathology depending on occupational activity, resulting in most cases more frequent in divers, in order to analyse the risk for divers, we performed a multivariate logistic regression analysis for explanatory rather than predictive purposes, using generalised musculoskeletal pathology as the dependent variable, with code 1 when at least one pathology was present and code 0 when none was present (Table 3).

Table 3: Logistic regression analysis.

Dependent variable: musculoskeletal pathology Yes=code 1 No=code 0

Independent factors	B	P	Adjusted OR	95% CI
Activity				
Fishing (reference)				
Diving	1.120	<0.001	3.06	1.63 – 5.73
Age (years)	0.042	0.025	1.04	1.01 – 1.08
Physical exercise	0.213	0.074	1.23	0.97 – 1.56
Seniority years	0.019	0.229	1.01	0.98 – 1.05
BMI	-0.030	0.231	0.97	0.92 – 1.01

B: regression coefficient p: statistical significance OR: Odds ratio CI: confidence interval
BMI: Body mass index

Source: Authors.

In Table 3 of the logistic regression model obtained using the enter method, we highlight that only two of the five variables introduced, activity and age, are associated with musculoskeletal disorders with statistical significance. Divers have three times the risk of suffering from musculoskeletal disorders compared to fishermen, adjusted for the other variables in the model (OR=3.06 95% CI=1.63 – 5.73), p< 0.001. Age was also significant, p=0.025, with the risk of musculoskeletal disorders increasing 1.04 times for each year of age (95% CI 1.01–1.08). The physical exercise variable, measured on a Likert scale with values from 1 to 4, with higher scores indicating less exercise, 4 indicating rare or no exercise and 1 indicating more than three times a week, is close to statistical significance, p= 0.074, with the risk of suffering from pathology increasing 1.23 times for each point on the scale, which means that lack of physical exercise implies risk, regardless of the worker's activity and age. The other two variables introduced into the model, seniority and BMI, do not appear to imply a risk of musculoskeletal pathology.

5. Discussion.

Work at sea is characterised by high physical demands, adverse environmental conditions and prolonged exposure to biomechanical risk factors that predispose workers to the development of musculoskeletal disorders. Jensen et al 2008 and Canals et al 2014 states that both professional fishing and diving are highly demanding work activities associated with load handling, repetitive movements, forced postures and working in unstable environments, factors widely recognised as determinants of musculoskeletal disorders in maritime workers [5,15,16].

In the case of fishermen, several studies have described a high prevalence of musculoskeletal disorders, especially in the lumbar and cervical regions and lower extremities, attributed to manual handling of loads, prolonged work on deck, and exposure to vibrations and adverse weather conditions [5,6]. Professional diving adds a number of specific factors to these physical demands, such as limited mobility and the adoption of non-physiological postures underwater as a result of the resistance to movement inherent in the aquatic environment, the use of heavy equipment and repeated exposure to hyperbaric environments, which constitutes a significant musculoskeletal risk profile such as Bratveit & Moen 22020 and Møllerløkken et al 2020 [16,17,18].

In this context, the results of the present study show that musculoskeletal disorders are common in both groups of sea workers, affecting 57.8% of divers and 47.2% of fishermen. Although this difference did not reach statistical significance in the bivariate analysis (p = 0.081), the multivariate analysis revealed that exposure to diving is associated with a more than threefold increase in risk (adjusted OR = 3.06; 95% CI: 1.63–5.73; p < 0.001), after adjusting for age, seniority, body mass index, and level of physical exercise. This finding highlights the existence of an independent effect of professional diving on the onset of musculoskeletal pathology.

Furthermore, analysis by anatomical location showed that musculoskeletal involvement was systematically more frequent in divers than in fish , with the lumbar spine, cervical spine and knees being the most affected regions. Gempp et al states that this distribution pattern coincides with that described in previous studies on professional divers, in which these areas are identified as particularly vulnerable due to the combination of mechanical overload, forced postures and repeated microtrauma associated with underwater work [18,19, 20].

In the observational and retrospective study of divers by Gempp et al. [20], 288 treated diving accidents were identified. Musculoskeletal pathology was mainly located in the shoulders, with 21 of the 25 cases subsequently followed up by magnetic resonance imaging.

In the present study, age was an independent risk factor for the development of musculoskeletal pathology (adjusted OR = 1.04). This finding is consistent with others that describe a progressive increase in musculoskeletal disorders associated with ageing, attributable to degenerative changes, loss of functional capacity and increased vulnerability of the osteoarticular system to Pfleger & Woolf and Briggs & Cross [21,22]. In the study by Flatmo, Groonning & Irgens, older divers and divers

with a high total number of dives had a higher prevalence of musculoskeletal disorders [11].

However, it is particularly relevant that the divers included in the study had a significantly lower mean age than the fishermen (39.1 versus 46.5 years; $p < 0.001$), which, in the absence of other factors, should be associated with a lower risk of musculoskeletal disorders. However, after multivariate adjustment, exposure to diving was associated with a more than threefold increase in risk (adjusted OR = 3.06), regardless of age and other potentially confounding variables. This result indicates that the effect of professional diving on the musculoskeletal system is intense enough to overcome the protective effect derived from younger age. These findings support the hypothesis that professional diving involves specific mechanisms of musculoskeletal damage, which could accelerate the onset of musculoskeletal e disorders at earlier ages compared to other maritime professions. Previous studies such as da Costa &V Vieira 2010 and Andersen 2012 have described how intense occupational exposures, such as professional diving, can accelerate the onset of musculoskeletal pathology [23,24].

Several studies have shown that regular physical exercise is a protective factor against the development of musculoskeletal disorders in the workplace. In particular, structured physical exercise programmes aimed at muscle strengthening and improving overall physical condition have been associated with a significant reduction in musculoskeletal pain and the incidence of pathologies related to jobs that require great physical effort to Marchand & Haines 2014 [25]. A recent systematic review of randomised clinical trials confirmed that the implementation of exercise programmes in workers consistently reduces musculoskeletal symptoms and improves functionality, especially in occupations with high physical demands to Macías – Toronjo et al 2025 [26].

In our study, 41.2% of divers exercise more than three times a week, compared to 28.3% of fishermen, resulting in a very significant difference, $p<0.001$. It is therefore particularly relevant that divers show a significantly higher risk of musculoskeletal disorders, with an adjusted OR of 3.06. This finding suggests that the beneficial effects of physical exercise are not sufficient to counteract the negative health impact of professional diving [19,20]. Unlike other maritime occupations, professional diving combines a high biomechanical load with specific environmental factors, such as restricted and difficult mobility in the underwater environment, the adoption of unnatural postures under the sea, the handling and carrying of heavy equipment, and continuous daily exposure to a hyperbaric environment, which substantially increases musculoskeletal overload to Skogstad et al 2017 [27].

In addition, it has been reported that repeated daily exposure to pressure changes, even without the prior existence of clinical decompression sickness, can contribute to degenerative joint processes and long-term subclinic musculoskeletal damage, mechanisms that are not present in other maritime professions, such as fishing to Briggs et al 2016 and Buzzacott & Denoble 2021 [22,28]. In contrast, although professional fishing carries a recognised musculoskeletal risk due to manual handling of loads, forced postures and repetitive movements, these tasks are performed on the surface and lack the hyperbaric factors and movement limitations inherent in underwater work [16]. Taken together, the occupational factors described could explain the higher risk observed in divers, even when a high-risk maritime profession such as fishing is used as a reference group.

6. Funding Declaration.

This present article was not funding.

7. Study Limitations.

Among the limitations, we can highlight that the design of an observational case-control study allows associations to be identified, but does not establish a cause-effect relationship. The consecutive non-random sample used, which included all workers who attended medical examinations over a period of one year, reduces the risk of selection bias, providing adequate representation of the population served in the usual practice of the Maritime Health Service, highlighting high coverage in the group of divers where there were no exclusions, which reinforces the internal validity of the results for the group of divers. Exclusions were limited to the group of fishermen, mainly due to the difficulty in understanding the text of the questionnaire, but we do not consider that this has influenced the magnitude of the association of the results found.

Future research, with longitudinal analytical study designs, such as cohort studies, would allow for a deeper understanding of the temporal relationship between exposure to work in a hyperbaric environment and the existence of occupational factors involved in the development of musculoskeletal disorders.

All participants signed an informed consent form.

8. Disclosures.

The authors have no competing interests to declarate that are relevant to this article.

Conclusions.

Exposure to professional diving is significantly associated with a higher probability of developing musculoskeletal disorders compared to other sea workers, such as fishermen. The magnitude of the association observed, which remained after adjusting for individual and occupational factors, suggests that professional diving is an occupational activity with an intense musculoskeletal load that deserves special attention in terms of occupational health surveillance. The findings reinforce the need to design preventive strategies adapted to the characteristics of underwater work, as well as to develop specific monitoring programmes for this group.

The fact that divers, who are significantly younger, have fewer years of professional activity and perform more physical exercise, present a significantly higher musculoskeletal risk than fishermen, allows us to confirm the existence of a specific occupational effect of professional diving.

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Conflict of interest statement.

The article has no duplicate publication or submission elsewhere; all authors have read and approved the manuscript; subject to acceptance, authors will transfer copyright to the Journal; and there is no ethical problem or conflict of interest. Submission of a manuscript to a BMC journal implies that all authors have read and agreed to its content and that the manuscript conforms to the journal's policies.

Declarations of interest.

None.

Informed consent.

Written informed consent was not required, as participants provided verbal consent at the time of undergoing the clinical procedures necessary for their work. Participation was entirely voluntary; those who did not wish to participate clearly stated so and were excluded from the study. This wording is consistent with the use of verbal consent when written consent is not feasible or appropriate, while preserving voluntariness, anonymity and the right to decline.

Ethics Committees.

Details on the procedure and setup were approved by the Ethics Committees of the University of Murcia. The study protocol was conducted in compliance with the Declaration of Helsinki.

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Credit author statement.

Laura Balanza-Cañete: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration and Funding acquisition.

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The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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