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Original article

Metabolic Syndrome and Cardiovascular Risk Factors in a Fishing Community in Southern Italy

Angela Stufano [1,*,†], Simona D'Amore [2,†], Valentina Schino [1], Paolo Danza [1], Ivo Iavicoli [3,‡], Piero Lovreglio [1,‡]

[1] Interdisciplinary Department of Medicine - Section of Occupational Medicine, University of Bari, Bari, Italy
[2] Department of Precision and Regenerative Medicine-Ionian Pole, University of Bari, Bari, Italy
[3] Department of Public Health, University of Naples Federico II, Naples, Italy

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A B S T R A C T

Background: Work organization and psychosocial factors influencing sleep patterns may be significant risk factors for developing obesity and metabolic syndrome (MetS). However, the impact on the health of working patterns in the fishing sector is not well characterized. The aim of the study is to determine the prevalence of MetS and its components in fishermen and to analyze occupational-specific risk factors contributing to metabolic alterations.
Methods: One hundred forty-three male fishermen from Apulia (Southern Italy) and 93 male university workers age-matched and from the same geographical area were included in this cross-sectional study. A questionnaire was administered to investigate socio-demographic variables, work activity, health status, and dietary habits. All subjects underwent clinical evaluation and blood sampling to depict their metabolic profile.
Results: A higher body mass index (BMI), waist circumference (WC), and waist-to-hip ratio ($p < 0.001$) were observed in fishermen than in university workers. No significant difference between the two groups was observed in the prevalence of MetS (15.4% fishermen vs 16.1% university workers) and its relevant diagnostic criteria, except abdominal obesity (42.7% fishermen vs 29.0% university workers, $p = 0.021$). The Castelli risk index, the monocyte/c-HDL ratio, and the Sokolow index were significantly greater in fishermen ($p < 0.001$). In the fishermen group, the total number of sleeping hours on working days was negatively correlated with WC ($r = -0.17$; $p = 0.04$), low-density lipoprotein cholesterol (c-LDL) ($r = -0.21$; $p = 0.02$), and the homeostasis model assessment (HOMA) index ($r = -0.19$; $p = 0.02$).
Conclusion: The higher prevalence of obesity and the imbalance of the metabolic profile observed in fishermen could be related to occupational factors, including the specific working pattern that influences their sleeping hours and sleeping-waking rhythms.

1. Introduction

Global estimates of prevalence, deaths, and disability-adjusted life years (DALYs) from 2000-2019 indicate an increase in metabolic diseases worldwide. In 2019, the number of cardiovascular disease (CVD) deaths attributable to metabolic factors reached 13.7 million, accounting for 73.7% of total CVD-related deaths [1]. Metabolic syndrome (MetS) is a significant public health challenge because it is closely associated with a higher risk of all-cause mortality, particularly CVDs and Type II diabetes mellitus (T2DM) [2]. Therefore, it is crucial to identify specific modifiable risk factors in different working populations to promote targeted primary

Valentina Schino: https://orcid.org/0009-0004-0930-3881; Paolo Danza: https://orcid.org/0009-0003-0808-2960
* Corresponding author. University of Bari, Bari, Giulio Cesare Square 4, 70125, Italy.
E-mail address: angela.stufano@uniba.it (A. Stufano).
† These authors equally contributed to the study.
‡ Co-Senior author.

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prevention of MetS. These risk factors include dietary habits, physical activity levels, job strain, long work hours, and sedentary behaviors [3].

The core components of MetS are hyperglycemia, central obesity, hypertriglyceridemia, low high-density lipoprotein cholesterol (c-HDL), and elevated blood pressure [4]. The complex pathogenesis of MetS involves environmental, genetic, and epigenetic factors [5]. High-calorie diets play a causative role, as visceral adiposity can trigger pathways leading to MetS [5]. Insulin resistance, chronic low-grade inflammation, and neurohormonal activation also play key roles in MetS progression and its subsequent transition to CVDs and T2DM [6].

Higher prevalence rates of obesity and MetS have been observed in occupations such as construction workers, police officers, and healthcare workers [7–9]. Work organization and related psychosocial factors, such as shift work, night work, work-related stress, fatigue, and sedentariness are significant risk factors for MetS development [10]. These factors influence stress levels and lifestyle habits, leading to poor dietary choices, sedentary lifestyles, and irregular sleep patterns. Chronic stress also triggers cortisol and other stress hormones, disrupting metabolic processes and promoting abdominal fat accumulation and insulin resistance [11].

In 2022, the Food and Agriculture Organization (FAO) estimated that 58.5 million people were employed in professional fishing and aquaculture worldwide [12]. Fishermen often work long hours in physically demanding environments, with irregular schedules and unpredictable patterns that lead to disrupted sleep and inconsistent mealtimes. These factors can contribute to inadequate rest and poor dietary habits, potentially increasing the risk of metabolic disorders and obesity [13]. However, the health effects associated with work organization and specific occupational risk factors, such as workload and irregular, prolonged working hours, have not been fully elucidated [14].

Due to the limited scientific data on the development of obesity, MetS, and CVDs in fishermen, this study aimed to investigate their prevalence among sea fishing workers compared to university workers. Additionally, it sought to explore potential associations between specific occupational risk factors, personal habits, and metabolic and cardiovascular alterations within these populations.

2. Materials and methods

2.1. Study design and participants

This cross-sectional study was conducted from May to September 2017 and included 143 male fishermen from Mola di Bari in Apulia, Southern Italy. The fishermen were compared to 93 age-matched male university workers from the University of Bari, who had never worked as sea fishers or engaged in night or shift work. The minimum sample size was calculated a priori by considering the prevalence of MetS in a previous study, accepting a margin of error of 2% and a 95% confidence interval [15]. The university workers were employed in indoor environments and primarily performed tasks involving visual display terminals (VDTs). Teaching professionals face occupational risks such as exposure to biological agents due to close contact with students and psychological stress related to classroom management.

University workers conducted their activities in regular daytime shifts of 8 hours per day. In contrast, fishermen had variable working hours depending on work demands and adverse weather conditions. Fishermen participating in the study were employed by a corporate entity within the fishing industry, which provides structured support and operational oversight in their work environment. All workers invited to participate in the study responded positively, resulting in a 100% response rate. The inclusion criteria were age over 18 years and more than one year of work history. The exclusion criterion was a lack of understanding of the Italian language.

The fishing industry in Apulia plays a crucial role in the region's economy, accounting for 12% of Italy's national fleet by number of vessels and 17% of the country's total fishing effort, as measured by days at sea. Apulia's significance is particularly pronounced in the trawling sector, where it represents 23% of the national fleet, making it one of the most productive fishing methods in the region. In terms of economic value, the Apulian fishing industry contributes 15% of the total national catch. The fleet comprises 1,474 vessels, with an average age of 38 years, and 62% of these boats are less than 12 meters in length. Artisanal fishing is the most common practice, with 860 vessels, representing 57% of the region's fleet. Despite this, trawling remains the dominant activity, generating 72% of the region's total fish production value. Employment in the trawling sector has remained steady, with approximately 1,449 workers [16].

2.2. Questionnaires

A comprehensive questionnaire was administered by trained medical personnel to gather information on medical history and socio-demographic variables. This included educational background, marital status, smoking habits, alcohol consumption, sports participation, and sleeping patterns on both working and rest days. Additionally, the questionnaire included questions about prior diagnoses of sleep disorders and sleep apnea syndrome. Physical activity was defined according to the World Health Organization (WHO) as any bodily movement produced by skeletal muscles that requires energy expenditure. This includes activities like walking, bicycling, and athletics, and involves 150-300 minutes of moderate-intensity aerobic physical activity or 75-150 minutes of vigorous-intensity aerobic activity, or a combination of both, per week [17].

The questionnaire also covered working activities, working hours, health status, and any ongoing therapy for cardiovascular, endocrine, metabolic, and mood disorders. Specific questions related to fishing practices included the type of fishing (trawling, gill net, or longline), the number and duration of fishing trips (daily, weekly, and/or monthly), activities performed at sea, and vessel characteristics.

Dietary habits were assessed using the Mediterranean Dietary Adherence Screener, a 14-item questionnaire validated for the Italian population. This questionnaire included two questions on food consumption habits (olive oil, white or red meat) and 12 questions on the frequency of food consumption typical of the Mediterranean diet (fruit, pulses, sofrito, vegetables, red wine, fish, red meat or sausages, nuts, animal fat, sugar-sweetened beverages, and commercial pastries) [18,19]. Each question was scored 0 or 1, with a total score ranging from 0 to 14.

2.3. Clinical assessment and blood sampling

Standardized procedures were used to measure anthropometric parameters such as height, body weight, and waist and hip circumference for both fishermen and university workers. Waist circumference (WC) was measured at the midpoint between the inferior part of the 12th rib and the anterior-superior iliac crests. Body weight was recorded to the nearest 0.01 kg using a calibrated digital balance (SECA 821), and height was measured to the nearest 0.1 cm with a wall stadiometer (SECA 225). Body mass index (BMI) was calculated as body weight in kilograms divided by height in meters squared (kg/m^2). Normal weight, overweight, and obesity were classified according to BMI values of 20.0-24.9, 25.0-29.9, and $\geq$30.0 kg/m^2, respectively. Hypertension was defined according to international criteria as systolic blood pressure ≥130 mmHg, diastolic blood pressure ≥85 mmHg, and/or treatment with antihypertensive agents.

Blood samples were collected in EDTA (Ethylenediaminetetraacetic acid) or serum tubes. After centrifugation at 3000 rpm under refrigerated conditions, plasma, and serum were obtained and stored at −20°C until analysis. Serum aliquots were used to evaluate lipid profiles, liver, and renal function, glucose metabolism, and 25-hydroxyvitamin D levels. Total cholesterol, high-density lipoprotein cholesterol (c-HDL), low-density lipoprotein cholesterol (c-LDL), triacylglycerol (TG) concentrations, uric acid, and glucose levels were measured using enzymatic tests (Sentinel Diagnostics, Milano, Italy). Insulin levels were assessed using enzyme-linked immunosorbent assay (ELISA) commercial kits (DRG International, Inc.; BD Biosciences ELISA reagent; Boster Biological Technology, Ltd.).

Type 2 diabetes mellitus (T2DM) was defined by glycosylated hemoglobin (HbA1c) > 6.5%, fasting plasma glucose (FPG) > 126 mg/dL, blood glucose >200 mg/dL, and/or diabetes treatment. Dyslipidemia cut-off values for male subjects were 40 mg/dL for c-HDL, 150 mg/dL for TG, and 200 mg/dL for total cholesterol. The Castelli index, a ratio used to estimate the risk of developing CVD, is calculated by dividing total cholesterol by c-HDL concentration [20].

A 12-lead electrocardiogram (ECG) was performed during rest for both fishermen and university workers using the Nihon Kohden Cardiofax®. All ECGs were evaluated by medical researchers using the Sokolow–Lyon index (SLI) [19], which was calculated and recorded. The Sokolow index assesses left ventricular hypertrophy (LVH) on an ECG. It is calculated by measuring the depth of the S wave in the V1 lead and the height of the R wave in either the V5 or V6 lead, with both measurements recorded in millimeters. The depth of the S wave in V1 is added to the height of the R wave in V5 or V6 to obtain the Sokolow index. A value exceeding 35 mm indicates LVH, while values below this threshold are generally considered normal [21].

Metabolic syndrome (MetS) was defined according to modified ATP III criteria, where an individual must meet at least three out of five diagnostic criteria: abdominal obesity (WC males >102 cm), hypertension (≥130/85 mmHg), low c-HDL (males <40 mg/dL), high TG (≥150 mg/dL), and impaired FPG (≥110 mg/dL or known T2DM) [4].

2.4. Statistical analysis

Statistical analysis was performed using the NCSS software (Kaysville, UT, USA). The Shapiro–Wilk test and graphical evaluations were used to assess the normal distribution of each variable. The Student's t-test was conducted to compare continuous variables between groups variables. The Pearson $\chi 2$ test was used for comparisons in terms of categorical variables. The relationship between continuous variables was analyzed by Pearson's correlation analysis. Logistic regression models were used to evaluate the impact of risk factors on the prevalence of MetS and its diagnostic criteria. In all the statistical tests, the null hypothesis was rejected when the p-value was lower than 0.05. To perform age matching, we used a tolerance matching strategy, in which a maximum acceptable age difference between fishermen and administrative employees is established (±5 years). The matching was performed in R using the package "MatchIt."

2.5. Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki, and it was consistent with ethical public health practice. Both fishermen and university workers were recruited on a voluntary basis during the health promotion programs performed according to the Italian Law concerning the protection of worker's health (D. Lgs. 81/2008; D. Lgs 271/99), so that an ethical committee approval was not requested. All the participants provided written informed consent for participation in the survey.

3. Results

The socio-demographic profile of the 143 fishermen (median age 44.0 years; range 21-69) and 93 university workers (median age 42.7 years; range 21-69) is shown in Table 1. University workers had a markedly higher level of education, with 100% having higher education, compared to none among the fishermen. Additionally, 82.0% of university workers practiced sports, significantly more than the 55.9% of fishermen. Regarding smoking habits, 58.7% of fishermen were smokers, while only 22.6% of university workers smoked, with university workers having a higher percentage of ex-smokers (54.8% vs. 22.4%). Lastly, fishermen reported a higher median weekly alcohol consumption of 10.0 units, compared to 5.3 units for university workers.

In terms of diet habits, fishermen adhered to the Mediterranean diet more closely than university workers (median score of 11 in

Table 1
Socio-demographic characteristics, comorbidities, sleeping and dietary habits in fishermen and University workers

Variables	Fishermen (n = 143)	University workers (n = 93)	p
Age			
Median (Range)	44.0 (21-69)	42.7 (20.7-69.3)	0.51
Working seniority Median (Range)	13.0 (1-47)	15.3 (1-45)	0.11
Educational status n (%)			<0.001
- Illiterate	2 (1.4)	0 (0)	
- Primary education	106 (74.1)	0 (0)	
- Secondary education	35 (24.5)	0 (0)	
- Higher education	0 (0.0)	93 (100)	
Marital status n (%)			<0.001
- Single	22 (15.4)	32 (34.3)	
- Married	105 (73.4)	50 (53.8)	
- Divorced	8 (5.6)	5 (5.4)	
- Widowed	0 (0.0)	2 (2.2)	
- Cohabitant	8 (5.6)	4 (4.3)	
Sport practice n (%)	80 (55.9)	77 (82.0)	<0.001
Smoking habits n (%)			<0.001
- Smokers	84 (58.7)	21 (22.6)	
- No smokers	27 (18.9)	21 (22.6)	
- Ex-smokers	32 (22.4)	51 (54.8)	
Alcohol consumption (Units/week) Median (Range)	10.0 (0.0-77.0)	5.3 (0.0-35.0)	<0.001
Comorbidities n (%)			
- Hypertension	23 (16.1)	13 (14.0)	0.5
- Type 2 Diabetes Mellitus	7 (4.8)	2 (2.2)	0.1
- Dyslipidaemia	11 (7.3)	4 (4.3)	0.7
Sleeping habits (hours)			
Median (Range)			
- at night on working days	3.0 (0.0-7.5)	7.0 (2.0-10.0)	<0.001
- total on working days	6.0 (2.0-11.0)	7.2 (4.5-10.0)	<0.001
- at night on rest days	7.2 (2.5-12.0)	7.7 (5.0-11.0)	0.007
- total on rest days	9.3 (4.0-14.0)	8.2 (5.0.12.0)	0.15
Mediterranean diet score Median (Range)	11 (6-13)	8.5 (4-13)	<0.001
Vegetable ≥2 servings/day n (%)	51 (35.7)	49 (53.3)	0.006
Fruit ≥3 servings daily n (%)	81 (56.6)	28 (30.4)	<0.001
Fish ≥3 servings/week n (%)	130 (90.9)	22 (23.9)	<0.001
Commercial pastries <3 servings/week n (%)	116 (81.1)	65 (70.7)	0.045
Olive oil ≥4 tablespoons/day n (%)	123 (86.0)	88 (95.7)	0.01

the fishermen group vs. 8.5 in the university workers, $p < 0.001$), consuming more fish (90.9% of fishermen consume ≥3 servings/week vs. 23.9% of university workers, $p < 0.001$) and fruit than university workers, who, on the other hand, had a higher intake of vegetables (53.3% vs. 35.7%, $p = 0.006$) and olive oil ($p = 0.01$).

No significant difference was observed in the prevalence of previously diagnosed hypertension, T2DM, and dyslipidemia, see Table 1. None of the participants had prior CVDs (data not shown).

Fishing activity was trawling in 82.2% of the fishermen, using gillnets in 6.0% and longlines in 2.6%, while 9.2% used both trawling and longline fishing. More than half of the fishermen (51.0%) performed only daily activity (fishing hours were generally between 12 am to 3 pm, 4-5 days per week), while 29.4% of the fishermen mainly performed weekly fishing campaigns (4-5 fishing days per week), and only 19.6% used to alternate the daily or weekly activities with monthly fishing campaigns (1 per year, lasting 10-45 days). Fig. 1 shows the different job tasks of the recruited workers.

Fishermen exhibited a higher median BMI ($p < 0.001$) and larger waist circumference ($p = 0.021$) than university workers, as well as a higher waist/hip ratio ($p < 0.001$). They also had higher levels of total cholesterol ($p < 0.001$) and LDL cholesterol ($p < 0.001$), along with elevated HbA1c ($p < 0.001$), insulin ($p = 0.003$), ALT (Alanine transaminase) ($p = 0.002$), GGT (Gamma-glutamyltransferase) ($p < 0.001$), uric acid ($p < 0.001$), and white blood cell count ($p < 0.001$), indicating increased metabolic and cardiovascular risks compared to university workers. The Castelli risk index and the monocyte/c-HDL ratio were significantly higher in fishermen ($p < 0.001$), indicating an elevated risk of cardiovascular disease, while the neutrophil/lymphocyte ratio was significantly greater in university workers ($p < 0.001$). The Sokolow index was also higher in fishermen ($p = 0.01$), suggesting a greater risk for heart conditions. Clinical and biochemical variables are shown in Table 2.

No significant difference was observed in the prevalence of MetS between the fishermen (15%) and university workers (16.1%) (Fig. 3).

The relationship between the clinical and the biochemical parameters, the lifestyle, and the work-related variables were analyzed separately in fishermen and university workers. A significant negative correlation between the total number of sleeping hours on the working days and WC (r = -0.17; $p = 0.04$), c-LDL (r = -0.21; $p = 0.02$), and homeostasis model assessment (HOMA) index (r = -0.19; $p = 0.02$) was observed in the fisherman group (Figs. 2a, b and 2c respectively). Instead, no significant correlations were found between the same parameters in the group of university workers.

Univariate logistic regression analysis was conducted to evaluate the association between selected risk factors and having MetS or MetS diagnostic criteria in the overall population (Table 3). Age was strongly correlated with increased MetS risk factors, such as elevated waist circumference ≥102 cm (OR = 1.08, $p < 0.001$), blood pressure ≥130/85 mmHg, or hypertensive treatment (OR = 1.08, $p < 0.001$), fasting glucose ≥100 mg/dl or treatment (OR = 1.06, $p < 0.001$), and MetS overall (OR = 1.09, $p < 0.001$). While fisherman occupation showed a weak association with increased waist circumference (OR = 1.73, $p = 0.053$), smoking showed a significant association with several MetS components, including waist circumference (OR = 1.02, $p = 0.001$), blood pressure ≥130/85 mmHg or hypertensive treatment (OR = 1.02, p = 0.009), fasting glucose (OR = 1.03, $p < 0.001$) as well as diagnosis of MetS (OR = 1.09, $p < 0.001$). Finally, total sleeping hours on working days were associated with waist circumference ($p = 0.003$) and fasting glucose ≥100 ($p = 0.022$).

Table 2
Clinical and biochemical variables of fishermen and university workers

Variables	Fishermen (n = 143) Median Range	University workers (n = 93) Median Range	p
BMI (kg/m^2)	27.5 18.1-48.3	25.7 19.9-34.4	<0.001
WC (cm)	98.0 75-136	94.0 76.0-151.0	0.021
Waist/Hip ratio	1.02 0.90-1.17	0.98 0.7-1.0	<0.001
Total cholesterol (mg/dl)	199.0 131-365	175.0 110.0-282	<0.001
c-HDL (mg/dl)	52.0 22-103	54.0 28.0-80.0	0.09
c-LDL (mg/dl)	125.5 69-218	99.5 51.0-199.0	<0.001
TGs (mg/dl)	94.5 14-233	91.0 31.0-770.0	0.15
FPG (mg/dl)	93.0 72-221	94.0 74.0-136.0	0.52
HbA1c (%)	5.5 4.5-12.8	4.7 3.0-6.8	<0.001
Insulin (μUI/ml)	8.6 0.1-31	7.9 1.9-52.5	0.003
ALT (U/l)	26.0 13-116	21.0 12-54	0.002
GGT (U/l)	33.0 14-233	25.0 12.0-86.0	<0.001
Uric acid (mg/dl)	5.8 2.7-10.2	5.0 3.0-7.8	<0.001
Homocysteine (mmol/l)	12.8 5.3-75.7	14.3 7.9-42.2	0.31
Vitamin D3 (ug/ml)	22.5 5.7-56.6	23.2 7.4-53.2	0.83
WBC (10^3/mm^3)	7.9 4.2-16.5	6.6 4.3-11.3	<0.001
Lymphocytes (%)	35.0 17.0-54.0	33.0 17-51	0.003
Monocytes (%)	9.0 5.0-15.0	9.0 5.0-14.0	0.15
Neutrophils (%)	51.0 33.0-72.0	55.0 34.0-75.0	0.01
Neutrophil/lymphocyte ratio	1.4 0.6-4.2	1.6 0.6-4.4	<0.001
Monocyte/c-HDL ratio	13.6 5.4.-37	11.0 4.8-29.5	<0.001
Castelli risk index	3.8 1.9-7.8	3.3 1,9-8.3	<0.001
Sokolow index (mm)	21.9 6.0-44.0	20.1 8.0-36.0	0.01

4. Discussion

This cross-sectional study revealed a higher prevalence of abdominal obesity and metabolic imbalance among fishermen

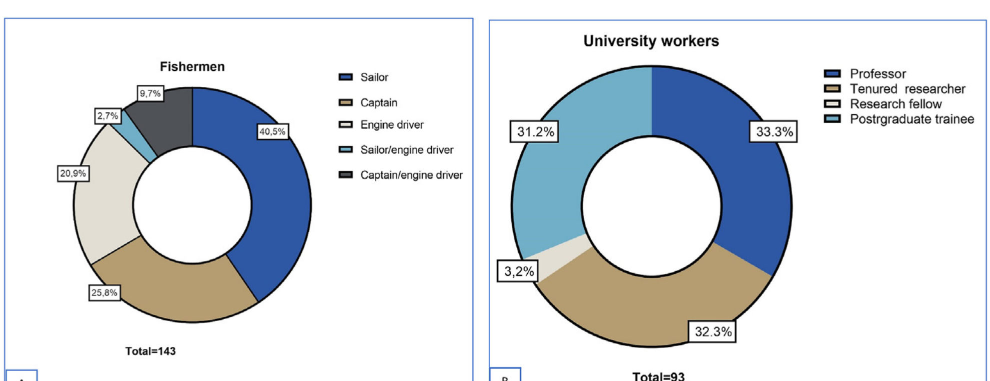

Fig. 1. Distribution of different tasks in the two groups (A: fishermen; B: university workers) of recruited workers.

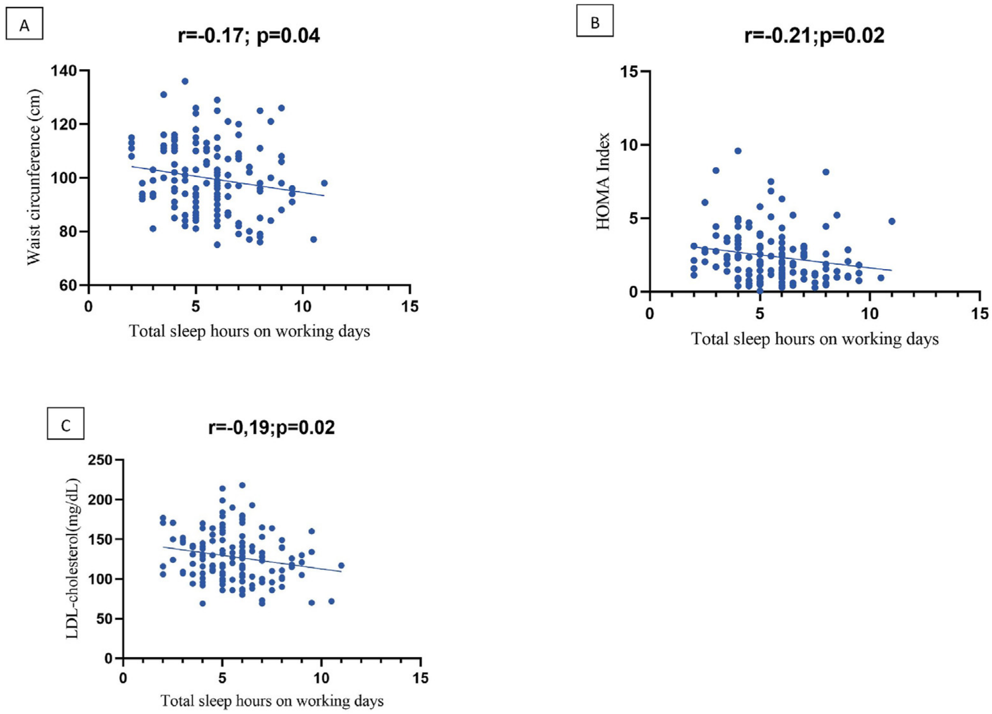

Fig. 2. Correlation analysis between waist circumference (cm), c-LDL (mg/dl), and HOMA index and total number of sleeping hours in fisherman (A, B and C). c-LDL, low-density lipoprotein cholesterol; HOMA, homeostasis model assessment.

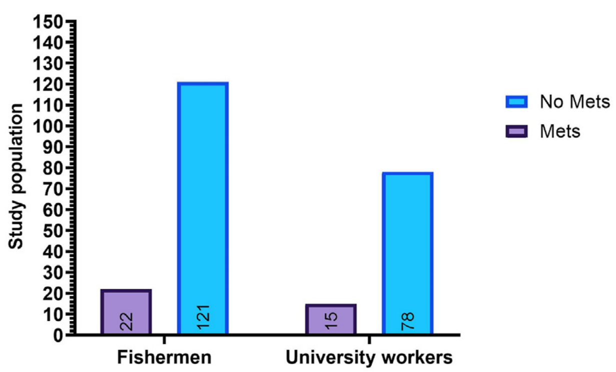

Fig. 3. Prevalence of metabolic syndrome in fishermen and university workers.

compared to university workers. These metabolic alterations appear to be influenced by factors such as age, Mediterranean diet adherence, smoking habits, sleep patterns, sedentary behavior, and lifestyle choices.

Globally, metabolic syndrome (MetS) affects approximately 20%-25% of the adult population, with prevalence impacted by age and personal habits [22]. In our study, the prevalence of MetS was not significantly different between fishermen and university workers, both of which showed a lower rate than that reported in the Italian population [23]. The relatively younger age of participants compared to those in previous reports may explain these findings.

Unhealthy eating habits and excessive calorie intake are linked to a higher prevalence of MetS and increased mortality from all causes [6]. In contrast, greater adherence to the Mediterranean diet is associated with a reduced risk of MetS, cardiovascular diseases (CVDs), and type 2 diabetes mellitus (T2DM). It also improves blood pressure, glucose-insulin balance, endothelial function, and inflammation markers. The higher adherence to the Mediterranean diet, especially dietary fish intake, observed in the fishermen's cohort may contribute to the relatively low MetS prevalence in this group [24].

Fishermen showed greater abdominal obesity, higher BMI, altered lipid profiles, and increased cardiovascular risk biomarkers compared to university workers. These findings align with previous studies reporting high abdominal obesity rates among fishermen [25,26]. Fishing involves prolonged, demanding labor, leading to significant physical exhaustion. After long hours of hauling nets, lifting heavy equipment, and navigating challenging maritime conditions, fishermen often lack the energy and motivation for additional physical activities. The intense, sporadic nature of their work relies heavily on anaerobic energy systems, potentially limiting opportunities for further physical exertion and contributing to obesity. Consistent with previous reports [27,28], only 55.9% of fishermen in our study reported engaging in sports, significantly lower than the 83.8% of university workers. A meta-analysis suggests that sedentary behavior increases MetS likelihood by 73%, as it reduces muscle lipoprotein lipase activity, leading to decreased triglyceride uptake and lower c-HDL levels [29].

Numerous studies link increased CVD prevalence and associated mortality among fishermen due to elevated risk factors such as smoking, obesity, and shift work, all observed in our fisherman group compared to university workers [20–31]. Key indicators like the Castelli index, monocyte to c-HDL ratio, and the Sokolow index are all higher in fishermen. The Castelli index indicates coronary plaque risk and is closely related to cardiovascular risk [32]. The monocyte to c-HDL ratio, a new indicator of subclinical inflammation, is elevated in CVDs and helps predict MetS [15]. The Sokolow index, derived from ECGs, assesses left ventricular hypertrophy (LVH), a condition marked by thickened heart ventricle walls, which heighten cardiovascular risk. The Sokolow index is valuable in cardiovascular risk assessment by identifying individuals at increased risk for heart attacks, strokes, and heart failure [33].

Table 3
Univariate logistic regression analysis for association between selected risk factors and having each single ATP criteria for the diagnosis of MetS

Parameter	Waist circumference ≥102 cm OR (95% CI) *p*	Blood pressure ≥130/85 mmHg or hypertensive drug treatment OR (95% CI) *p*	c-HDL <40 mg/dl or drug treatment for low c-HDL OR (95% CI) *p*	TGs ≥150 mg/dl or drug treatment for elevated TGs OR (95% CI) *p*	Fasting glucose ≥100 mg/dl or drug treatment for elevated glucose OR (95%CI) *p*	Metabolic syndrome OR (95% CI) *p*
Age	1.08 (1.05-1.11) <0.001	1.08 (1.05-1.12) <0.001	1.01 (0.98-1.06) 0.491	1.02 (0.99-1.05) 0.260	1.06 (1.03-1.09) <0.001	1.09 (1.05-1.13) <0.001
Occupation	1.73 (0.99-3.00) 0.053	0.67 (0.38-1.18) 0.160	1.33 (0.52-3.44) 0.552	1.14 (0.59-2.21) 0.705	1.10 (0.61-2.01) 0.752	0.95 (0.46-1.93) 0.878
Length of service	1.00 (0.98-1.03) 0.927	1.02 (0.99-1.05) 0.176	1.04 (1.00-1.08) 0.059	1.01 (0.98-1.05) 0.448	1.03 (1.00-1.06) 0.070	1.01 (0.98-1.05) 0.520
Sleep hours at night on working days	0.90 (0.80-1.01) 0.076	1.06 (0.93-1.20) 0.384	1.10 (0.90-1.35) 0.339	0.88 (0.76-1.01) 0.070	0.94 (0.83-1.07) 0.325	0.97 (0.83-1.13) 0.694
Total sleeping hours on working days	0.79 (0.67-0.92) 0.003	1.00 (0.85-1.17) 0.952	0.99 (0.76-1.27) 0.908	0.87 (0.73-1.05) 0.145	0.82 (0.69-0.97) 0.022	0.82 (0.67-1.01) 0.061
Total sleeping hours on rest days	0.94 (0.81-1.10) 0.445	0.96 (0.8-1.13) 0.650	1.28 (0.99-1.65) 0.058	1.00 (0.83-1.20) 0.994	0.96 (0.81-1.13) 0.600	0.93 (0.76-1.14) 0.483
Absence of sport practice	0.74 (0.52-1.04) 0.085	1.10 (0.76-1.58) 0.620	1.13 (0.64-2.02) 0.674	0.73 (0.48-1.12) 0.145	0.69 (0.47-1.02) 0.059	0.83 (0.52-1.31) 0.419
Mediterranean diet score	1.16 (1.01-1.33) 0.036	0.95 (0.82-1.09) 0.449	0.99 (0.79-1.24) 0.907	1.01 (0.85-1.18) 0.954	1.15 (0.99-1.34) 0.072	1.03 (0.86-1.23) 0.728
Packs of cigarettes per year	1.02 (1.01-1.04) 0.001	1.02 (1.01-1.03) 0.009	1.01 (0.99-1.03) 0.289	1.01 (1.00-1.02) 0.066	1.03 (1.01-1.04) <0.001	1.03 (1.02-1.05) <0.001
Units of alcohol per week	0.99 (0.97-1.02) 0.521	0.97 (0.94-1.00) 0.057	0.99 (0.95-1.03) 0.570	1.00 (0.97-1.02) 0.759	1.01 (0.99-1.03) 0.395	0.98 (0.94-1.02) 0.257

In the study cohort, logistic regression analysis showed that a waist circumference (WC) greater than 102 cm correlated with total sleep hours at night during workdays. Similarly, low c-HDL levels were associated with total sleep hours during rest days. Additionally, a negative correlation between the HOMA index, abdominal circumference, and c-LDL levels with total sleep hours on working days was observed in fishermen. Various maritime shift systems force work hours during the circadian nadir, requiring sleep at suboptimal times [34]. Environmental factors like vibrations and noise complicate rest aboard ships. Previous studies show that sleep at sea is often fragmented, with lower efficacy than on land [35]. Crew reductions on modern vessels increase workloads and disrupt sleep patterns for remaining workers [30]. Sleep deprivation and irregular sleep due to shift work contribute to obesity and cardiometabolic issues by exacerbating insulin resistance and obesity [9].

Irregular mealtimes, common in fishing activities, also harm metabolic health. They cause internal circadian misalignments in hormone secretion, like cortisol, leptin, and ghrelin, raising obesity and cardiometabolic disease risks [36,37]. Our analysis found smoking habits correlated with increased WC. Smoking and secondhand smoke exposure are common among fishermen [25,38]. Although the relationship between smoking and obesity is complex [39,40], smoking seems to increase WC, waist-to-hip ratio, and visceral fat accumulation [41].

Moreover, the fishing industry operates under strict fisheries management regulations that influence various aspects of fishing practices, including the working conditions and health of the fishermen [42]. The participants in this study were employed by a cooperative, which means they work within a collectively governed structure rather than as independent operators or under a corporate entity. This cooperative model can create unique pressures, as members must adhere to shared operational guidelines and collective decisions that impact their schedules and workload. Such pressures, combined with the need to meet regulatory requirements, often lead to irregular hours and reduced sleep opportunities [42]. Unlike corporate employment, where structured support systems might be more prevalent, cooperative-employed fishermen may experience a different set of challenges and support mechanisms. Understanding these dynamics is essential for assessing the feasibility of implementing health and wellness programs tailored to the cooperative fishing environment.

This study has several limitations. It was conducted in a single Italian corporation and included only male subjects, as no female fishermen were available. The cross-sectional design limits the ability to infer causality from observed associations, and the nonrandom participant selection may reduce sample representativeness, impacting the generalizability of the findings. Additionally, the general anamnestic questionnaire was not validated, which could further limit generalizability. While questions on sleep disorders and sleep apnea were included, the absence of a standardized tool for assessing these conditions may have affected the accuracy and depth of the sleep-related data. While confounding variables were controlled, factors like diet, lifestyle, education, and socioeconomic status may not have been fully addressed. Future research should explore these aspects to provide a more comprehensive understanding of fishing activities' health implications.

Despite limitations, this study is significant as it is the first to report obesity, cardiovascular risk factors, MetS, and its diagnostic criteria in fishermen, considering dietary and sleeping habits. This is crucial given the large global fishing workforce. The study also highlights how unique work organizations influence cardiometabolic risk, expanding our understanding of work-related impacts on cardiovascular and metabolic diseases.

In conclusion, our research underscores the need for a comprehensive approach, like the Total Worker Health® (TWH) program, to address work-related and non-modifiable risk factors. The TWH program integrates occupational risk prevention and health promotion tailored to specific occupational groups. Unifying these efforts into a single policy is essential to safeguard worker safety, improve health, and boost productivity [43].

CRediT authorship contribution statement

Angela Stufano: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Simona D'Amore:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Schino Valentina:** Writing – review & editing, Visualization, Investigation, Conceptualization. **Paolo Danza:** Writing – review & editing, Investigation. **Ivo Iavicoli:** Writing – review & editing, Validation, Supervision, Project administration, Conceptualization. **Piero Lovreglio:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Data curation, Conceptualization.

Availability of data and materials

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

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Conflicts of interest

The authors declare no competing interests.

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