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Matteo Riccò[1]
Carlo Signorelli[2]

PERSONAL AND OCCUPATIONAL RISK FACTORS FOR CARPAL TUNNEL SYNDROME IN MEAT PROCESSING INDUSTRY WORKERS IN NORTHERN ITALY

[1] Provincial Agency for Health Services of the Autonomous Province of Trento, Trento, Italy
Department of Prevention, Occupational Health and Safety Unit

[2] University of Parma, Parma, Italy
Department of Biomedical, Biotechnological and Translational Sciences

Abstract

Background: Carpal tunnel syndrome (CTS) is a musculoskeletal condition that often impairs the fitness to work. Our aim is to retrospectively evaluate the association between physical exposures in meat processing industry in Northern Italy and the CTS, taking into account non-occupational factors. **Material and Methods:** A cross-sectional study was performed to include 434 workers (236 males, 198 females, 37.0±10.6 years old, working age: 12.6±10.8 years) from meat processing industries. Signs and symptoms were collected at the compulsory occupational medical surveillance. Occupational risk factors were assessed through a questionnaire and direct assessment by investigators. Adjusted odds ratios (OR_{adj}) for factors of interest were estimated through binary logistic regression. **Results:** Diagnosis of the CTS was reported for 61 out of 434 subjects (14.1%) for an incidence of 11.3/1000 person-years. In general, signs and symptoms for the CTS were associated with the following demographic factors: smoking history (OR = 1.909, 95% confidence interval (CI): 1.107–3.293), previous traumas of the upper limb (OR = 3.533, 95% CI: 1.743–7.165), hypothyroidism status (OR = 7.897, 95% CI: 2.917–21.38) and, in the case of female participants only, previous pregnancies (OR = 2.807, 95% CI: 1.200–6.566) as well as a personal history of oral contraceptive therapy and/or steroidal replacement therapy (OR = 11.57, 95% CI: 4.689–28.56). The carpal tunnel syndrome cases were associated with the following occupational factors (> 4 h/day): forceful hand exertion (OR_{adj} = 3.548, 95% CI: 1.379–9.131), repeated trauma of the hand (OR_{adj} = 3.602, 95% CI: 1.248–10.395), repeated movements of the wrist (OR_{adj} = 2.561, 95% CI: 1.100–5.960). **Conclusions:** Increasing levels of hand activity and force were associated with the increased CTS prevalence among participants. Recommendations have to be provided in order to reduce occupational exposure to these risk factors and improve medical surveillance. Med Pr 2017;68(2):199–209

Key words: cumulative trauma disorders, peripheral nervous system disease, electromyography, carpal tunnel syndrome, nerve compression syndromes, meat-packing industry

INTRODUCTION

With an estimated prevalence of 1–5% in the general population, the carpal tunnel syndrome (CTS) is considered to be the most common form of peripheral nerve entrapment neuropathy, representing a significant driver of workers' compensation costs, lost time, lost productivity and disability [1–3]. In the US only, medical costs for the CTS have been estimated to amount to 2 billion dollars annually, primarily due to surgical releases [4], and the median sick leave from the CTS is 25–27 days, which is longer than any other work-related disorder except fractures [5,6].

Clinically, the CTS has been defined as a complex of symptoms (i.e., pain, numbness, or tingling on the anterior surface of the index, middle, or radial half of the ring finger, frequently associated with weakness of hand grip, and nocturnal pain and/or numbness) resulting from compression of the median nerve at the carpal tunnel formed by the carpal bones and the transverse ligament [7–9]. Although age, female gender, body mass index (BMI), diabetes mellitus, rheumatoid arthritis, hyperthyroidism, and previous wrist surgery, have been repetitively recognized as main risk factors for the CTS [6,10,11], sound evidence associates such disorder with workplace factors such as repetitive/prolonged hand-intensive activities, forceful exertions, awkward and/or static postures, vibrations, temperature extremes, and localized mechanical stress CTS [3,7,8,12–16].

Not coincidentally, the prevalence of electrophysiological confirmed that the CTS in working populations is generally higher than in the general population [17],

and in certain working groups it may peak up to around 20% [18–20]. In this regard, meat processing industry has been repetitively identified as a high risk environment for the CTS, as it typically requires significant exposure to repetitive hand movements to hang, kill, clean, eviscerate, cut, package and box meat at a rapid pace and at relatively low environmental temperature [6,21–23]. Not coincidentally, the CTS prevalence in meat industry has been reported to be 15–24% [2,3,10,18–20,23–27], and some reports suggest that even higher estimates may be found depending on the operative definition applied by researchers [20,21,28,29].

Italian meat industry employs around 30 000 workers in 5000 establishments across the country, representing about 5% of pork 10% of poultry production in the EU. The average size of the enterprises is small, with a median of 12 employees per establishment, even smaller than the European median size of 20 employees, ultimately forcing the workers to perform several tasks during the working shift, implying a relatively low degree of specialization [30–32].

Despite these specificities, data regarding the CTS epidemiology in meat processing industry in Italy is still lacking [33]. The objective of this study has therefore been to investigate the epidemiology of the CTS among workers of small-sized meat processing establishments in Northern Italy, and to assess whether personal risk factors may be associated with the CTS diagnosis.

MATERIAL AND METHODS

Workers from 31 meat processing plants referring to one occupational health service from Northern Italy (median size = 11 employees) were recruited between January 2012 and December 2013. This convenience sample included only employees directly involved in meat processing tasks, such as cutting, eviscerating, washing, trimming, deboning, receiving, hanging, killing, plucking, packing, sanitation, chilling, eventually encompassing a total of 473 consecutive subjects. Inclusion criteria included being at least 18 years old, Italian speaking, working at least 24 h/week for at least 3 years of seniority in meat processing industry. Exclusion criteria included contraindication to receiving nerve conduction studies (NCS), such as known coagulopathies, bloody discrasias, current oral anticoagulant therapy, or an implanted cardiac defibrillator.

All the subjects were informed about the study and people agreeing to participate signed an informed con-

sent. The study protocol included: occupational risk assessment, clinical evaluation and electrodiagnostic study of the median nerve. Clinical and electrodiagnostic examinations were performed by different operators, blinded to each other's results.

Clinical assessment

The clinical evaluation of each worker was performed by a properly trained clinician. All patients received a full medical assessment in order to obtain a complete musculoskeletal evaluation. Patients referring to symptoms such as numbness, tingling, burning or pain in at least 1 of 1st, 2nd or 3rd digit, palm or wrist pain and having a positive Phalen's test and/or positive reverse Phalen's test, and/or positive Tinel's test, and/or positive Carpal Compression test, were considered clinically possible cases of the CTS and further evaluations with ultrasonography and/or NCS were performed [15,34–38]. For the purposes of this survey, the NCS diagnosis of the CTS was achieved by motor latencies > 4.0 ms, sensory latencies > 3.7 ms, amplitudes < 20 μV, or a conduction velocity < 50 m/s with evidence of fibrillation [35]. A case of the CTS was defined by a worker, not by hand.

A questionnaire was administered to all workers in order to standardize data collection about demographic characters, pain condition, medical history (i.e., thyroid problems, kidney failure, diabetes mellitus, previous pregnancies). Among clinical data, history of previous traumas (i.e., either penetrating or closed injuries associated with at least 10 days of restricted/impaired movements of the arm) or surgical procedures of the upper limb were accurately collected. Data about drug consumption was also recalled, with particular attention to β-blockers, non-steroidal anti-inflammatory drugs (NSAIDs) and, for females only, oral contraceptive therapy (OCT: at least 5 years of cumulative use) and steroidal replacement therapy (SRT). Regular physical activity was defined following the World Health Organization (WHO) recommendation for those who are 18–64 years old [39].

Exposure assessment

Information on present and former employment, actual employment status, tasks held at the meat industries, and self-reported ergonomic exposures, was also obtained from the questionnaire. They were then asked to identify and characterize which tasks they performed during the working shift (i.e., cutting, eviscerating, washing, trimming, deboning, receiving, hanging, killing, plucking, packing, sanitation, chilling).

Working tasks details collected from the questionnaires and workplaces were eventually assessed in order to identify whether the workers were exposed to the following risk factors for at least 4 h/day:

- working in cold environment (i.e., t < 18°C),
- weight lifting having the National Institute for Occupational Safety and Health (NIOSH) lifting index > 1.0,
- forceful hand exertion (≥ 10 N pinch force or ≥ 45 N grip force),
- thumb pressing (i.e., activities requiring the prolonged application of force trough the thumb either on tools or objects),
- forearm rotation (i.e., activities requiring supination/pronation of the forearm > 45°),
- the use of vibrating tools (i.e., visible hand/arm vibration during the use of vibratory hand tools),
- prolonged wrist bending (i.e., sustained wrist flexion/extension > 30°),
- forced position of the wrist (i.e., axial deviation of wrist from neutral position),
- repeated trauma of the hand (i.e., repeated mechanical compression of the soft tissues in the hand following the use of tools or objects which press against the palm),
- repeated movement of the wrist (i.e., cycle time of less than 30" or more than 50% of the cycle time involved performing the same type of fundamental cycles).

All exposure variables were analyzed as dichotomous ones (i.e., present/absent).

Statistical analysis

Continuous variables were compared using the t-test whereas the Chi^2 test was used for comparing categorical variables. The univariate analysis was used for calculating the odds ratios (OR) and the 95% confidence intervals (CI). A binary logistic regression model was then applied in order to calculate the correspondent adjusted odds ratios (OR$_{adj}$) for occupational risk factors having a p < 0.20 in the univariate analysis. The model assumed diagnosis of the CTS as an independent variable, and included sex, age and working age as covariates, as well as all personal risk factors that in the univariate analysis were statistically associated with the CTS positive status (p < 0.05). All statistical analyses were performed using SPSS version 24.0 (IBM Corp.).

Ethics

The study was performed as a part of a compulsory health assessment at the workplace: the procedures were performed only in order to fully assess the clinical status and the workers' fitness to work, and would be performed even without the conduction of the study. Therefore, no preliminary evaluation by the Ethical Committee was necessary. However, as clinical and personal data had been collected and elaborated, all participants gave their written consent and subjects refusing their consent were excluded from the study population.

RESULTS

The Table 1 shows the demographics and personal characteristics of the participants. The overall response rate was 91.8% including a total of 434 workers, and the average age of participants was 37.0±10.6 years old, with a mean seniority of 12.6±10.8 years. The study population included predominantly subjects of male sex (N = 236, 54.4%) and Italian origin (N = 301, 69.4%), ha-

Table 1. Demographic data of meat processing industry workers in the study of personal and occupational risk factors for carpal tunnel syndrome (CTS), Northern Italy, 2012–2013

Respondents characteristics	Respondents			p	OR	95% CI
	total (N = 434)	asymptomatic (N = 373)	with clinically assessed CTS (N = 61)			
Sex [n (%)]						
males	236 (54.4)	209 (88.6)	27 (11.4)	0.087	0.623	0.361–1.075
females	198 (45.6)	164 (82.8)	34 (17.2)			
Migration background [n (%)]						
Italian-born people	301 (69.4)	254 (84.4)	47 (15.6)	0.160	1.573	0.833–2.969
foreign-born people	133 (31.6)	119 (89.5)	14 (10.5)			
Age [years] (M±SD)	37.0±10.6	35.6±10.0	46.0±9.8	< 0.001		

Table 1. Demographic data of meat processing industry workers in the study of personal and occupational risk factors for carpal tunnel syndrome (CTS), Northern Italy, 2012–2013 – cont.

Respondents characteristics	Respondents			p	OR	95% CI
	total (N = 434)	asymptomatic (N = 373)	with clinically assessed CTS (N = 61)			
Seniority [years] (M±SD)	12.6±10.8	11.1±10.1	21.6±10.7	< 0.001		
Body mass index (BMI)						
M±SD [kg/m^2]	24.4±3.7	24.3±3.8	24.3±3.1	0.368		
overweight (BMI > 25 kg/m^2) [n (%)]	161 (37.1)	133 (82.6)	28 (17.4)	0.125	1.531	0.887–2.644
obesity (BMI > 30 kg/m^2) [n (%)]	38 (8.8)	35 (92.1)	3 (7.9)	0.253	0.500	0.149–1.678
Personal risk factors [n (%)]						
smoking history (current or previous)	162 (37.3)	131 (80.9)	31 (19.1)	0.019	1.909	1.107–3.293
previous trauma(s) of the upper limbs	43 (9.9)	29 (67.4)	14 (32.6)	< 0.001	3.533	1.743–7.165
previous surgery of the upper limbs	3 (0.7)	2 (66.7)	1 (33.3)	0.336	3.083	0.275–34.550
no physical activity	399 (91.9)	348 (87.2)	51 (12.9)	0.158	0.495	0.213–1.148
previous diagnosis of thyroid disease	17 (3.9)	9 (52.9)	8 (47.1)	< 0.001	7.897	2.917–21.380
previous diagnosis of diabetes	4 (0.9)	3 (75.0)	1 (25.0)	0.527	2.056	0.210–20.100
previous pregnancies*	114 (57.6)	88 (77.2)	26 (22.8)	0.014	2.807	1.200–6.566
previous use of oral contraceptive therapy / hormone replacement therapy (OCT/HRT)*	68 (34.3)	41 (60.3)	27 (39.7)	< 0.001	11.570	4.689–28.560
previous use of β-blockers	15 (3.4)	10 (66.7)	5 (33.3)	0.029	3.241	1.068–9.835
chronic use of non steroidal anti-inflammatory drugs (NSAIDs)	30 (6.9)	21 (70.0)	9 (30.0)	< 0.001	21.230	9.107–49.510

M – mean, SD – standard deviation, OR – odds ratio, CI – confidence interval.

* Female participants only.

ving a mean body mass index (BMI) of 24.4±3.7 kg/m^2. Twenty-one cases had a personal history of comorbid conditions (4.8%), including the previous diagnosis of thyroid disease (N = 17, 3.9%) and diabetes mellitus (N = 4, 0.9%). A total of 35 workers referred to regular physical activity (8.1%), and most of the participants were never smokers (N = 272, 62.7%).

Among the participants (Table 2), most worked in a cold environment (i.e., < 18°C) (N = 281, 64.7%), and performed activities that required weight lifting for at least 4 h/day (N = 262, 60.4%) whereas the use of vibrating tools was identified for 127 out of 434 workers (29.3%). Daily tasks requiring the prolonged application of force trough the thumb either on tools or objects, and repeated mechanical compression of the soft tissues in the hand were identified in 39.9% (N = 173) and 27% (N = 117) of the participants, respectively. Focusing on hand/wrist movement and postures, forceful hand exertion was identified in 55.3% patients (N = 240) whereas 33.9% (N = 147) of the participants performed activities implying supination/pronation of the forearm > 45° from neutral position, 26.5% (N = 115) of workers had daily tasks including prolonged wrist

bending, 16.6% (N = 72) performed activities that forced the axial wrist posture, and 12.2% (N = 53) executed repeated movement of the wrist.

The workers meeting the case definition for the CTS diagnosis were 61 out of 434 subjects (14.1%), and more precisely 27 out of 236 males (11.4%) and 34 out of 198 females (17.2%, p = 0.087), for an estimated incidence of 11.3/1000 person-years (9.6/1000 person-years among males, and 13.3/1000 person-years among females, p = 0.208). For 34 of them (55.7%) clinical diagnosis was confirmed by the ultrasonography and/or the nerve conduction study.

The mean age of the 61 employees with the CTS, independent of sex, was 46±9.8 years old, with a seniority of 21.6±10.7 years whereas asymptomatic workers were significantly younger (35.6±10.0 years, p < 0.001) with a shorter employment history (11.1±10.1 years, p < 0.001). In the univariate analysis, no significant relation was found between ethnicity and prevalence of the CTS (69.4% Italian-born people (IBP) vs. 31.6% foreign-born people (FBP), p = 0.160). Current and previous smokers (N = 162) had prevalence of the CTS signs and symptoms greater than never-smokers

Table 2. Occupational risk factors for carpal tunnel syndrome (CTS) in the meat processing industry workers, Northern Italy, 2012–2013

Risk factor	Respondents [n (%)]			p	OR (95% CI)	OR_{adj} (95% CI)
	total (N = 434)	asymptomatic (N = 373)	with clinically assessed CTS (N = 61)			
Work in a cold environment (< 18°C)	281 (64.7)	241 (85.8)	40 (14.2)	0.884	1.043 (0.590–1.843)	–
Weight lifting (NIOSH lifting index > 1)	262 (60.4)	226 (86.3)	36 (13.7)	0.927	0.937 (0.540–1.625)	–
Forceful hand exertion (≥ 10 N pinch / ≥ 45 N grip)	240 (55.3)	197 (77.1)	43 (17.8)	0.015	2.134 (1.187–3.838)	3.548 (1.379–9.131)
Thumb pressing (activities requiring the prolonged application of force trough the thumb either on tools or objects)	173 (39.9)	149 (86.1)	24 (13.9)	0.929	0.975 (0.560–1.697)	–
Forearm rotation (activities requiring supination/ pronation of the forearm > 45° from neutral position)	147 (33.9)	130 (88.4)	17 (11.6)	0.285	0.722 (0.397–1.314)	
Use of vibrating tools (visible hand/arm vibration during the use of vibratory hand tools)	127 (29.3)	111 (87.4)	16 (12.6)	0.574	0.839 (0.455–1.548)	–
Repeated trauma of the hand (repeated mechanical compression of the soft tissues in the hand following the use of tools or objects which press against the palm)	117 (27.0)	105 (89.7)	12 (10.3)	0.018	2.234 (1.191–4.189)	3.602 (1.248–10.395)
Prolonged wrist bending (wrist flexion/ extension > 30°)	115 (26.5)	92 (80.0)	23 (20.0)	0.047	1.849 (1.047–3.266)	1.740 (0.530–5.710)
Forced positions of the wrist (deviation of wrist from neutral position)	72 (16.6)	55 (76.4)	17 (23.6)	0.167	0.625 (0.320–1.222)	0.321 (0.077–1.336)
Repeated movements of the wrist (cycle time of less than 30" or more than 50% of the cycle time involved performing the same type of fundamental cycles)	53 (12.2)	39 (73.6)	14 (26.4)	0.001	3.240 (1.611–6.518)	2.561 (1.100–5.960)

NIOSH – The National Institute for Occupational Safety and Health.
Adjusted odds ratios (OR_{adj}) were calculated through binary logistic regression for occupational risk factors having a p < 0.20 in univariate analysis.
Other abbreviations as in Table 1.

(N = 272, 19.1% vs. 11.0%, p = 0.019, OR = 1.909, 95% CI: 1.107–3.293). Personal history positive for previous traumas of the upper limb was recalled by a total of 43 workers (9.9%), and more specifically by 67.4% of the CTS cases and 32.6% of asymptomatic workers (p < 0.001, OR = 3.533, 95% CI: 1.743–7.165).

The body mass index of the CTS cases and the CTS negative workers was similar (24.3±3.8 kg/m² vs. 24.3±3.1 kg/m², p = 0.368), and overweight (defined as BMI ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) status was not significantly associated with the CTS diagnosis (OR = 1.531, 95% CI: 0.887–2.644 and OR = 0.500, 95% CI: 0.149–1.678, respectively). Conversely, a previous diagnosis of hypothyroidism was more frequently reported in the CTS positive than in the CTS negative cases (OR = 7.897, 95% CI: 2.917–21.38).

Regarding pharmacological history, chronic use of NSAIDs and β-blocker therapy previous to the diagnosis of the CTS was recalled by 30 (6.9%) participants and 15 (3.4%) participants, respectively. Both exposures were positively associated with the CTS status (p < 0.001).

Among female participants, a personal history including one or more pregnancies previous to the beginning of clinical symptoms as well as personal history of oral contraceptive therapy/hormone replacement therapy (OCT/HRT) (p < 0.001, OR = 11.57, 95% CI: 4.689–28.56) were more frequently referred to by the CTS positive cases (76.5% vs. 53.7%, OR = 2.807, 95% CI: 1.200–6.566).

Focusing on occupational factors (Table 2), the CTS cases were associated with the following occupational factors (> 4 h/day): forceful hand exertion (OR = 2.134, 95% CI: 1.187–3.838), repeated trauma of the hand (OR = 2.234, 95% CI: 1.191–4.189), prolonged wrist bending (OR = 1.849, 95% CI: 1.047–3.266), and repeated movements of the wrist (OR = 3.240, 95% CI: 1.611–6.618) whereas the CTS positive and negative cases had similar exposure to factors such as working in a cold environment (OR = 1.043, 95% CI: 0.590–1.843), weight lifting (OR = 0.937, 95% CI: 0.540–1.625), thumb pressing (OR = 0.975, 95% CI: 0.560–1.697), forced positions of the wrist (OR = 0.625, 95% CI: 0.320–1.222) and forearm rotation (OR = 0.722, 95% CI: 0.397–1.314) as well as the use of vibrating tools (OR = 0.839, 95% CI: 0.455–1.548).

Eventually, the logistic regression was modeled including age and working age, personal risk factors (including: history of previous traumas/previous surgery of the upper limb, chronic diseases, smoking history,

regular physical activity at the time of the survey). Adjusted estimates for forceful hand exertion (OR$_{adj}$ = 3.548, 95% CI: 1.379–9.131), repeated trauma of the hand (OR$_{adj}$ = 3.602, 95% CI: 1.248–10.395), repeated movements of the wrist (OR$_{adj}$ = 2.561, 95% CI: 1.100–5.960) retained statistical significance.

DISCUSSION

The work-related CTS has been reported in meat processing workers since 1983, and the following research has confirmed a significantly increased occupational risk [3,40]. Available studies on meat industry workers have defined the CTS by different criteria, such as recalling of symptoms, examination findings in a physical examination, nerve conduction studies, neuromuscular ultrasound studies, response to surgery, or by a combination of these parameters, resulting in large differences in epidemiological data [3,6,20,21,33,41,42]. Our definition of the CTS was constructed to reflect what may be called a common clinical consensus of what is usually understood as the CTS, and showed a prevalence of 14.1%, and an incidence of 11.3 cases/1000 person-years. This incidence is more than three times the one reported in the general population of Siena during the decade 1991–1998, a study that ultimately based the CTS diagnosis on nerve conduction studies, and somehow similar to other reports from meat processing industry [3,6,20,21,33,41–43]. However, our results should be cautiously interpreted.

First of all, we must stress that the CTS is a very common condition in the general population, and our sample was relatively small, obtained through a sort of convenience sampling, as included workers who were enlisted for the compulsory medical surveillance of enterprises referring to the same occupational medicine service [2,37,44–47]. However, as the participation rate was > 90%, selection bias was presumptively reduced [6].

Secondly, the percentage rate of comorbid conditions otherwise associated with the CTS, such as diabetes and hypothyroidism, was relatively small both for cases and asymptomatic workers, and probably it represents a healthy worker effect [8,9,38,43,48–51], eventually suggesting a significant "survivor bias." In other words, as our study included people who were able to maintain their jobs and lost those who left the employment because of clinical conditions or other reasons, we may have ultimately underestimated both incidence and prevalence of the CTS.

Finally, it should be stressed that a clear consensus about the best clinical criteria for diagnosis of the CTS still does not exist [35,51,52]. In our study, the clinical assessment [15,34–38] was followed by ultrasonography and/or NCS study, and only 55.7% of cases were eventually defined as the CTS-confirmed cases, suggesting that the clinical estimates may be biased by a significant overdiagnosis. As previously reported, despite the general reliance on NCS/electromyography as diagnostic gold standards, when electrodiagnostic tests are performed in order to validate the results of the physical exams, they are potentially biased by the clinical diagnosis and its inherent variability [52,53]. In other terms, an even more cautious approach is required not only when comparing our results to national estimates but also when referring to similar studies [2,3,10,18–20,23–27].

In our sample, traditional risk factors for the CTS such as higher age and BMI were unrelated to prevalence and incidence of the CTS. It is possible that the manual labour performed in the various tasks associated with meat processing industry represents a greater risk factor for the CTS, as suggested by the greater seniority of the CTS cases, and previously reported in other studies about the CTS epidemiology in occupations requiring forceful exertion [1,2,21]. Actually, we observed a significant risk of the CTS for workers performing task implying forceful hand exertion, repeated trauma of the hand, and repeated movements of the wrist, but our results are partially consistent with previous studies, as we failed to recognize a correlation of the CTS with the use of a vibrating tool, otherwise described as a main risk factor [2,3,6,20,21,33,41,42].

These figures may require several explanations. First of all, long-term forceful or repetitive hand and/or wrist activities would lead to increased interstitial fluid pressure within the carpal tunnel. An increased carpal tunnel pressure would in turn compress its contents, which may lead to poor blood circulation. Over time, ischaemia ultimately causes long-lasting effects such as irreversible damage to the flexor synovial cells and median nerve synovial thickening, with extensive fibrosis and demyelination of the median nerve [2,7–9,12,54]. Hand-arm vibrations may also cause similar effects but modern and up-to-date vibrating tools have significantly reduced workers' exposure [27,54–57].

Moreover, Italian meat processing industry is very heterogeneous not only in terms of size but also regarding the application of modern ergonomics in the design of workplaces [33]. In order to minimize this effect, we focused on the specific tasks performed by participants,

eventually identifying the specific risk factors. Their presence received a double evaluation, as the questionnaire-collected self-assessment was associated with a specific technical appraisal of workplaces but this assessment was unable to accurately characterize previous exposures, and the CTS represents an impairment of body structures associated rather than simply caused by cumulative exposure to work, working environments and several personal risk factors [58]. In this regard, as we adjusted the obtained odds ratios for the most known risk factors of the CTS (i.e., demography, lifestyle factors, medical conditions), the observed association between work-related risk factors and the CTS are unlikely due to confounding by these factors [3,6,20,21,33,41,42].

Despite previous studies that suggested an increased risk for the CTS in female workers, we also found a slightly greater risk for female workers both in terms of prevalence and incidence, the difference being not statistically significant. Among female participants, history of the OCT/HRT and previous pregnancies were more frequently reported by the CTS. These associations are consistent with previous evidences, as the hormonal status has been identified as a significant risk factor for the CTS [59–61]. The use of β-blockers has been more controversially reported among the risk factors for the CTS since the late 1980's, and the underlying mechanism may similarly result from the drug-related fluid retention and oedema [51,62,63]. The interpretation of the strong association of NSAIDs use with the CTS status appears more controversial. In brief, it is plausible that these figures should be assumed as consequently rather than causatively related: despite NSAIDs are useful only with a substantial degree of tendonitis or tenosynovitis associated with the CTS, patients frequently self-medicate with oral NSAIDs [51,64].

The higher risk for the CTS after upper limb trauma and/or upper limb surgery should also be accurately evaluated, as usually interpreted as a rare issue [65,66]. In general, studies about the CTS and trauma have focused on short term complications of trauma involving a pressure increase in the carpal tunnel [66]: as anything that irritates or compresses the median nerve in the carpal tunnel space may lead to carpal tunnel syndrome, these findings hint for a more accurate recall of previous personal history in the case of the CTS patients.

CONCLUSIONS

In our study, encompassing 434 workers, both prevalence and incidence of the CTS were roughly similar

to previous reports from meat processing industry, and up to 3 time the estimates for Italian general population, supporting a significant effect of occupational risk factors on the CTS natural history. Personal risk factors such as smoking history, the OCT/HRT, previous pregnancies, metabolic comorbidities, use of β-blockers, and previous history of traumas and surgical procedures at the upper limb, were associated with the increased risk for the CTS. Our results suggest that strenuous and repetitive nature of meat processing, and in particular forceful hand exertion, repeated trauma of the hand, and repeated movements of the wrist significantly increase the risk for the CTS. As several tasks associated with these risk factors during meat processing may be only marginally automatized or semi-automatized in order to reduce workers' exposure, our results ultimately reinforce the recommendations to employ a rigorous job rotation schedule in which employees rotate between jobs that use different muscle groups, and to increase screening for the CTS in order to monitor and ultimately improve employee health.

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