INTERNATIONAL JOURNAL OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH
2017, VOL. 23, NO. 4, 282–290
https://doi.org/10.1080/10773525.2018.1474420

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Carpal tunnel syndrome prevalence: an evaluation of workers at a raw poultry processing plant

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ABSTRACT

Objectives: Evaluate the prevalence of carpal tunnel syndrome (CTS) among workers at a raw poultry processing plant and categorize jobs on the basis of hand activity and force.
Methods: A cross-sectional survey among 191 workers assessed CTS defined by self-reported CTS symptoms, a hand symptom diagram, and measurements of nerve conduction parameters. We categorized jobs based on American Conference of Governmental Industrial Hygienists' (ACGIH®) limits for hand activity and force, and examined the relationships with CTS occurrence.
Results: A total of 64 workers (34%) had CTS after adjusting for non-occupational factors. Overall, 81% of jobs were above the ACGIH action limit; 59% were above the ACGIH threshold limit value®. CTS prevalence did not differ significantly between exposure groups (PR = 0.82, p = 0.35).
Conclusions: These findings suggest that poultry processing jobs continue to be hazardous with workers at risk for CTS. Recommendations for the study population were provided to reduce exposure and CTS risk among workers.

ARTICLE HISTORY
Received 30 May 2017
Accepted 2 May 2018

KEYWORDS
Carpal tunnel syndrome; ergonomics; poultry processing; nerve conduction study; hand activity level

Introduction

Musculoskeletal disorders (MSDs) are injuries or disorders of the muscles, nerves, and/or tendons that can affect many parts of the body. Carpal tunnel syndrome (CTS) is an MSD that results from compression of the median nerve in the wrist causing slowing of median nerve conduction. When the median nerve is compressed, pain, burning, numbness, and tingling may result in the hand. Across all U.S. industries, the U.S. Bureau of Labor Statistics reported that CTS resulted in one of the highest number of lost workdays (28 median days away from work per case), while all MSDs resulted in an estimated 32.2 cases per 10,000 workers and a median of 12 days-away-from-work in 2015 [1]. Additionally, work-related MSDs have been shown to result in approximately 1 million workers losing time off of work each year and are a major financial burden to the general public, resulting in at least 50 billion dollars in work-related expenses each year [2].

Personal risk factors, such as medical conditions (obesity, diabetes mellitus, hypothyroidism, and pregnancy), have been positively associated with CTS [3–7]. Age (greater than 40 years old) has also been positively associated with CTS [3,5,7], and to a lesser extent, female sex [7,8]. There are limited studies that define the relationship between ethnicity/race and CTS. In one study, the authors found that there was no significant association between CTS and ethnicity/race [9]; however in another study, authors found that white race was a risk factor for CTS [10].

The U.S. is the world's largest poultry producer and second largest poultry exporter [11]. In 2016 and 2017, approximately 9 billion birds were slaughtered for human consumption by about 238,000 U.S. poultry employees (not including other animal-slaughtering employees) [12,13]. According to the U.S. Department of Agriculture National Agricultural Statistics Service, in 2016, the U.S. poultry industry produced 8.78 billion broiler chickens, 102 billion eggs, and 244 million turkeys all up between 1% and 5% from 2015 [14]. In the 1960s, 85% of broiler chickens were sold as whole birds. At that time, only 13% were sold as cut-up parts and by the 1990s it was up to 56% [15]. Automation of the evisceration process and other equipment improvements have reduced manual work in some areas of the modern poultry industry. However, much of the work on raw poultry processing lines (including deboning and cut-up processes) involves rapid, repetitive, and forceful hand and wrist movements. Repeated studies in this industry find a high prevalence of MSDs (e.g. CTS) [16–18].

Among the major ergonomic risk factors with strong evidence for CTS are a combination of repetitive and forceful hand movements, vibration, and awkward postures [19–21]. Poultry processing involves a combination of highly repetitive and forceful movements, extreme postures, and refrigerated

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temperatures; all factors which place employees at increased risk for upper extremity work-related MSDs [17,22]. As part of a National Institute for Occupational Safety and Health (NIOSH) health hazard evaluation (HHE) requested by plant management, NIOSH investigators documented ergonomic risk factors for CTS as part of the ergonomic and health assessment for MSDs among poultry-processing workers at two raw poultry plants in 2013 and 2015 [23–25]. The employer submitted the request to fulfill a U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS) requirement to participate in the USDA Hazard Analysis and Critical Control Point (HACCP) Inspection Models Project (HIMP). A HIMP waiver permits plant personnel to conduct carcass sorting and trimming instead of FSIS inspectors. However, HIMP requires offline FSIS inspectors to determine if the plant is meeting relevant performance standards [26]. An HHE is a workplace evaluation requested by an employer, employees, or employee representatives to determine whether workers are exposed to hazardous materials or conditions. These HHEs were done as a public health response following the federal regulations found in Title 42, Code of Federal Regulations, Part 85 (https://www.gpo.gov/fdsys/pkg/CFR-2017-title42-vol1/xml/CFR-2017-title42-vol1-part85.xml). As a public health response, per the guidelines of Title 45 Code of Federal Regulations Part 46, this evaluation was determined to not require review by an institutional review board.

As part of the NIOSH HHE in 2015, we evaluated ergonomic risk factors for MSDs by reviewing injuries and illnesses reported on Occupational Safety and Health Administration (OSHA) Logs and in daily medical clinic logs (data not shown). We also conducted ergonomic evaluations, surveyed employees, and did nerve conduction study (NCS) testing [25]. The primary focus of this paper was to evaluate the magnitude of work-related CTS and prevalence of hand or wrist symptoms among poultry-processing workers in specific jobs and its relation to hand force and hand activity levels (HALs) of the jobs. More details about our findings and recommendations can be found in the HHE (https://www.cdc.gov/niosh/hhe/reports/pdfs/2014-0040-3232.pdf).

Material and methods

Poultry plant description

At the time of the HHE, the plant processed approximately 177,000 birds per day or 885,000 birds over a 5-day workweek. The live birds weighed on average 8 pounds. The plant operated two evisceration lines across two production shifts. Each evisceration line was running at approximately 91 birds per minute. The plant had 697 full-time employees on either the first or second production shift (excluding supervisors and non-production employees). Overall, 342 full-time employees worked in the receiving/picking (41), evisceration (including liver harvest, 75), debone direct (168), and thigh line (58) departments on either the first or second production shift. There were no regular job rotation patterns and certain jobs had performance-based incentive programs at the plant.

Population

The ergonomic assessment of job tasks focused on hand and wrist activity. For the epidemiologic assessment, selection of employees included all of the poultry receiving/picking and evisceration employees including liver harvest; and due to scheduling constraints a simple random sample (40%) of debone direct and thigh line employees. These departments were selected based on information gathered during the initial visit, literature reviews, and knowledge from previous poultry evaluations. Participation was voluntary. After obtaining written informed consent from participants, employees filled out a questionnaire in their preferred language (English, Spanish, or Creole). On the whole, 96% (191/199) of employees invited to participate completed a questionnaire and NCS.

Epidemiologic assessment of carpal tunnel syndrome

The epidemiologic case definition for CTS included neuropathic hand or wrist symptoms and NCS based on prior work of other investigators [17,18,27,28]. Participants had to meet all of the following criteria to be considered a CTS case:

- Answered "yes" on a questionnaire to pain, burning, numbness, or tingling in the hands or wrists, occurring more than three times or lasting 7 days or longer in the past 12 months and,
- Marked or shaded the location of their symptoms in the median nerve distribution area on a modified Katz [28] hand symptom diagram and,
- Had abnormal median nerve conduction (median mononeuropathy) [27] in the symptomatic hand(s) as determined by neurologist-interpreted NCS.

A participant was considered to have evidence of CTS if at least one hand met the case definition. We also measured each participant's height and weight to calculate body mass index (BMI) according to the following formula [29]:

Table 1. Abnormal median nerve conduction measures [Burt et al. 2011[a]].

Abnormal if meet Criteria A and (Criteria B or Criteria C)

Criteria	Indicators	Latency or amplitude
A Slowed latency in median nerve (one of the indicators present)	● wrist to index finger sensory latency	>3.7 ms[b]
	or	
	● mid palm to wrist sensory latency	>2.2 ms
	or	
	● motor latency	>4.4 ms
B Normal distal ulnar nerve latency and amplitude (both indicators present)	● wrist to little finger sensory amplitude	≥10 µV[c]
	and	
	● wrist to little finger sensory latency	≤3.7 ms
C Distal median nerve latency > distal ulnar latency	● median wrist to index finger *minus* ulnar wrist to little finger latency	difference >1.0 ms
	or	
	● median mid palm to wrist *minus* ulnar mid palm to wrist latency	difference >0.5 ms

$$\text{BMI} = \text{weight in pounds} \times 703/(\text{height in inches})^2$$

Questionnaires

NIOSH investigators used a questionnaire to obtain information on employees' demographics (sex, age, ethnicity/race), work history, and duties (work hours, length of employment). In addition, information on medical history thought to be associated with CTS (thyroid problems, kidney failure, diabetes mellitus, pregnancy, obesity) and the presence, frequency, and duration of neuropathic symptoms (pain, burning, numbness, or tingling in their hands or wrists). Pictures were used of certain medical conditions (e.g. ganglion cyst, trigger finger) when translation of medical terms to other languages was difficult or did not exist to rule out other causes of hand symptoms.

Participants who reported hand or wrist symptoms in the past 12 months also completed a hand symptom diagram adapted from Katz et al. (1990) [28]. Participants indicated the location of their hand or wrist symptoms by marking or shading areas on the diagrams. These diagrams were used to identify symptoms associated with a classic median nerve distribution. Results from the diagrams were classified into four hand categories: positive right hand only, positive left hand only, positive both hands, or negative both hands (based on the median nerve distribution used in a couple of studies) [27,28]. Two NIOSH investigators independently evaluated the hand symptom diagrams. Both were blinded to the identity of the individual or knowledge of their job title, medical information, and questionnaire responses. The NIOSH investigators had 100% agreement with classifying the marked or shaded areas in the hands and/or wrists.

Nerve conduction studies

An electrodiagnostic technologist, certified by the American Association of Electrodiagnostic Technologists, performed bilateral NCS on participants following established standard guidelines [30,31]. The technologist was blinded to the participants' job title, medical information, and questionnaire responses. Participants' hands were warmed to 32°C with a radiant lamp, and median and ulnar orthodromic motor and sensory studies were performed on a XLTEK NeuroMax 1002 NCS machine. Measurements for the purpose of electrode placement were made with the wrist held straight and the fingers extended.

A board-certified neurologist, also blinded to the participants' job title, medical information, and questionnaire responses, reviewed the NCS tracings. The neurologist interpreted results as either normal or abnormal based on established criteria, as shown in Table 1 [27]. Abnormal median nerve conduction was defined as a slowed latency or a decreased amplitude in the median nerve and either (1) normal distal ulnar nerve latency and amplitude or (2) distal median nerve latency greater than ulnar nerve latency. Also, severity of CTS (Stevens 1997 criteria) was determined using categorization of NCS results [32]. Participants were provided with their individual NCS results (including tracings), an interpretation of their meaning, and NIOSH contact information if they had questions or concerns.

Ergonomic exposure assessment

We focused on classifying jobs based on ergonomic risk factors related to hand and wrist activity. Videos were collected of all manual job tasks in the receiving/picking, evisceration, debone direct, and thigh line departments ($n = 32$ job tasks). Videos were used to document the jobs for assessment by multiple raters [33]. Both evisceration lines and all five debone lines were running at the same speed. Therefore, we randomly chose one employee to record for each of 32 job tasks. We recorded at least 3 min of video for each job task, long enough to see several complete work cycles.

Four NIOSH ergonomists reviewed the entire video for each job task and independently scored the repetition and force for each job task. We used the following approach:

- To assess repetition, we used the HAL scale to separately rate repetitiveness for right and left hands during at least five complete work cycles [33].
- To assess force, we separately rated peak exertion of the right and left hands using the modified Borg CR-10 scale [34].
- To address ratings that differed between the NIOSH ergonomists, we discussed our observations and came to a joint decision.

We compared our measurements of hand activity and force with the action limit (AL) and threshold limit value (TLV®) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH®) [33]. The TLV uses the average HAL and peak hand force to determine conditions it is believed that nearly all workers can be exposed to repeatedly without adverse health effects [33]. This TLV was validated in two large cohort studies and predicted both CTS symptoms and CTS confirmed by NCS [35], and confirmed that forceful hand exertions significantly increased the risk of CTS [36]. Additionally, we chose to compare HAL and CTS similar to prior research by other NIOSH investigators [27].

We used the HAL and force ratings to calculate a ratio using the following formula [37]: Ratio = Force/(10–HAL)

We used the calculated ratio to determine an exposure value for each job task. If the ratios for the hands were different, we used the more protective (higher) ratio. We classified job tasks into the following three exposure groups:

- Ratios below 0.56 were below the AL (exposure group 1).
- Ratios 0.56–0.78 were at or above the AL to the TLV (exposure group 2).
- Ratios above 0.78 were above the TLV (exposure group 3).

We were not able to calculate a time-weighted average exposure for each employee because some employees performed a variety of job tasks within a department daily, and it was not feasible to follow each employee individually for an entire shift to be able to document each task. Thus, to look at the relationship between exposure to ergonomic risk factors and prevalence of CTS, participants were grouped into exposure groups on the basis of the department in which they reported working at the time of the evaluation. The departments were given an exposure score using a weighted average based on the number of employees performing a job and the exposure group for that job.

Statistical analysis

All statistical analyses were done using SAS Version 9.3 (SAS Institute Inc., Cary, NC).

We determined descriptive statistics for demographic, occupational, and non-occupational information. The prevalence of CTS, specific hand or wrist symptoms, and abnormal NCS results were calculated.

We used a chi-square test to evaluate the relationship in an unadjusted analysis between CTS and exposure group (based on the department's weighted average). We then used log-binomial regression to evaluate the relationship adjusting for confounders. We examined CTS prevalence by exposure groups. Adjusting for sex, age, BMI, and diabetes mellitus, we found similar results to the unadjusted analysis; therefore, we are only presenting the unadjusted results. Results with $p < 0.05$ were considered statistically significant.

Results

Epidemiologic assessment of carpal tunnel syndrome

Table 2 shows the demographics and personal characteristics of the participants. The average age of participants was 40 years (range: 20–70), and participants predominantly were Spanish-speaking (43%) and Hispanic (46%). The percent of participants with a BMI ≥30 was 39% (75 of 191) which is

Table 2. Characteristics of participants (n = 191).

Age (years)	Mean 40 (range: 20–70)
Body mass index	Mean 29.6 (range: 20–56)
	Number (%)
Sex	
Male	95 (50)
Female	96 (50)
Ethnicity/race	
Black	58 (30)
Creole	38 (20)
Hispanic	88 (46)
White	4 (2)
Other	3 (2)
Language[a]	
Spanish[b]	82 (43)
English	76 (40)
Creole[c]	33 (17)
Medical conditions[d]	
Diabetes mellitus	16 (8)
Thyroid problems	10 (5)
Kidney failure	3 (2)
Currently pregnant[e]	3 (3)

[a]Questionnaire language as selected by participants.
[b]6 participants who reported being Hispanic preferred to take the questionnaire in English.
[c]5 participants who reported being Creole preferred to take the questionnaire in English.
[d]Reported medical conditions ever diagnosed by a physician.
[e]Out of 94 responding females, 3 did not know.

considered to be "obese" (CDC considers BMI ≥30 to be "obese") [29]. Three women reported being pregnant.

Participants were asked how many hours they usually worked and length of employment. The participants reported an average of 40 hours (range: 28–48.5) a week and had been at this plant for an average of 6 years (range: 0.06–42). There was no statistically significant relationship between CTS and years worked at this plant.

In addition, participants were also asked about having medical conditions ever diagnosed by a physician. Of 191 participants, 16 (8%) reported that a physician diagnosed them with diabetes mellitus, 11 (6%) CTS, 10 (5%) thyroid problems, 8 (4%) hand or wrist tendonitis, 7 (4%) trigger finger, 6 (3%) a ganglion cyst, and 3 (2%) kidney failure.

The prevalence of hand or wrist symptoms in the last 12 months (a component of our CTS case definition) was 58% (110/191); of these, 63 (58%) reported having hand or wrist symptoms in the last 7 days. A total of 145 of 191 (76%) employees had abnormal NCS results, indicating the presence of median mononeuropathy. Also, most of these abnormal NCS results were rated by the board-certified neurologist as "moderate" 64% (93/145). Overall, 79% of the 145 employees with abnormal NCS results were abnormal in both hands, 14% were abnormal in the right hand only, and 6% were abnormal in the left hand only.

On the whole, 34% (64/191) of participants met the case definition for CTS. Of these 64 participants, 59 (92%) had moderate or severe median mononeuropathy in at least one hand (using the most severe hand). We found bilateral CTS in 27 (42%) of these 64 participants.

Table 3. Prevalence of carpal tunnel syndrome, by personal characteristics and conditions.

Variable	N	Number of carpal tunnel syndrome cases (%)
Sex		
Female	96	38 (40)
Male	95	26 (27)
Age		
≤40	109	35 (32)
>40	82	29 (35)
Body mass index ≥ 30		
Yes	75	34 (45)
No	116	30 (26)
Diabetes mellitus[a]		
Yes	16	5 (31)
No	175	59 (34)
Ethnicity/race[b]		
Black	58	25 (43)
Hispanic	88	28 (32)
Creole	38	8 (21)

[a]Participants who reported ever having a physician diagnosis of diabetes mellitus.
[b]Self-reported ethnicity/race on the questionnaire.

Of the 64 participants who met our CTS case definition, 44 (69%) reported being awakened from sleep (another clinical manifestation of CTS) because of hand and wrist symptoms in the past 12 months.

Table 3 shows the prevalence of CTS by several personal characteristics and conditions. CTS prevalence was similar for those above age 40 compared to those at or below 40. In addition, CTS prevalence was similar for those who reported and those who did not report ever having a physician diagnosis of diabetes mellitus. Only one of the three participants who reported kidney failure met our CTS case definition. We did not find statistically significant relationships between CTS and sex ($p = 0.07$) or CTS and ethnicity/race (Black, Creole, Hispanic) ($p = 0.08$). We did find a statistically significant association between obesity and CTS ($p = < 0.01$).

Ergonomic assessment

We collected videos for 32 job tasks in the receiving/picking, evisceration, debone direct, and thigh line departments. The job tasks are listed by department and exposure group in Table 4. Overall, the majority of job tasks across these departments (59%) were in exposure group 3, i.e. above the ACGIH TLV. All job tasks in the evisceration department were in exposure group 3, but the other departments had job tasks in all three exposure groups. However, because there were so few job tasks and employees in the lower exposure groups and the rotation schedule, the receiving/picking, evisceration, and thigh line departments were all categorized into exposure group 3. The debone-direct department was categorized into exposure group 2. The distribution of all participants by exposure group is shown in Table 5.

Association between ergonomic risk factors and CTS

The distribution of CTS cases among work departments showed that the debone direct department had the highest prevalence (25 of 66, 38%) of CTS cases and thigh line department had the lowest prevalence (2 of 18, 11%), but the differences between work departments were not statistically significant. Table 6 shows the distribution of CTS cases by exposure group (none of the departments we evaluated were in exposure group 1). CTS prevalence did not differ significantly between the two exposure groups (prevalence ratio = 0.82, $p = 0.35$).

Discussion

In this raw poultry processing plant, NIOSH investigators found that 34% of workers in highly repetitive, forceful jobs had CTS [25]. A similar NIOSH investigation [23,24] at another poultry plant found comparable results (42% of workers with CTS) based on the same case definition [23,24], which included

Table 4. Job tasks by area and department categorized by exposure group.

Department	Exposure group 1	Exposure group 2	Exposure group 3
Receiving and Picking	Jockey driver Dumper operator	Backup killer Backup rehang	Forktruck driver Live hang
Evisceration			Backup vent opener Viscera pull Presenter Inspector helper Liver pull Liver sort Viscera removal Final trim Salvage Salvage-vacuum
Debone direct	Tender clip Breast skinner loader	Loader Wings Breast trim Breast pull	First cut Second cut Tender score
Thigh line	Debone machine loader Grader	Packer	Skinner loader Weigher Trim-Whizard Trim-scissors

Table 5. Distribution of participants by exposure groups (n = 191).

Exposure groups	Number (%)
Group 2 (AL[a]–TLV[b])	66 (35)
Group 3 (>TLV)	125 (65)

[a]AL: action limit for the ACGIH TLV for hand activity and force.
[b]TLV: ACGIH threshold limit value for hand activity and force.

Table 6. Prevalence of carpal tunnel syndrome, by exposure group (n = 191).

Exposure groups	N	Number of carpal tunnel syndrome cases (%)
Group 2 (AL[a]–TLV[b])	66	25 (38)
Group 3 (>TLV)	125	39 (31)

[a]AL: action limit for the ACGIH TLV for hand activity and force.
[b]TLV: ACGIH threshold limit value for hand activity and force.

symptoms, a hand symptom diagram, and objective NCS measurements.

The physiologic hallmark for assessing clinical CTS is median mononeuropathy at the wrist that is determined by a NCS (using mostly conduction latency/velocity parameters) [38]. Studies have defined clinical and epidemiologic CTS case definitions by using symptoms in combination with physical examination, NCS alone, symptoms alone, or a combination of these criteria. While 76% of participants had an abnormal NCS in at least one hand, only 34% met our CTS case definition. This percent difference may reflect a subclinical entity associated with CTS and NCS which may help to identify disease early in the disease process because symptoms may vary over time. There may be an underreporting of symptoms or a normal variant of some individuals to have asymptomatic median nerve conduction slowing down. Workers who are exposed to ergonomic risk factors and have an abnormal NCS may be at risk for developing CTS, despite initially lacking symptoms of CTS [39,40]. Although an abnormal NCS is an important criterion for the diagnosis of CTS, most asymptomatic people with abnormal NCS remain asymptomatic [39,40]. A recent pooled study of 2396 U.S. workers evaluating associations between personal and workplace factors and median nerve conduction latency at the wrist found that abnormal NCS without symptoms was associated with the same biomechanical exposures that are related to CTS [38].

While we found that CTS was significantly associated with obesity, as has been previously found, work-related ergonomic factors (such as hand activity and force) remained important risk factors for CTS. CTS prevalence did not differ significantly between exposure groups, but a high percentage of jobs at the poultry-processing plant we evaluated required highly repetitive and forceful hand work. To address these elevated exposures, ACGIH recommends using professional judgment as a means to identify workplace controls for employees working in low temperature environments. Although OSHA has provided guidance for preventing MSDs, including CTS, in the poultry industry since early 2000 [41], more work and research in this area and industry could be done to further prevent CTS.

This evaluation was a cross-sectional survey that measured health outcomes and exposures at a specific point in time. Cross-sectional surveys provide useful data for supporting inferences of cause and effect but cannot confirm the direction of the relationship. Our ergonomic assessment was strengthened by having four ergonomists independently scoring HAL for job tasks [33]. Some exposure misclassification may have resulted because the exposure assessment was based on subjective measuring of hand activity and force. Additionally, only one employee per job task was evaluated. Time weighted averages were not calculated because there was not a distinct rotation pattern and there were incentive programs in place, which did not allow some employees to rotate. Inherent in this type of evaluation is the potential for survivor bias (i.e. we may have focused our evaluation on those workers who remained on the job [the survivors] and not captured workers who may have left their job because of an injury, illness, or another reason). Such survivor bias, which is of particular concern in the poultry industry because of relatively high turnover rates among workers, may result in underestimating the prevalence of injuries or illnesses, including MSDs such as CTS. Also, due to practical constraints around scheduling and logistics, we were able to invite only 199 production employees to participate in our evaluation and therefore we captured only a subset of the 697 full-time production employees.

CTS in active workers is unlikely to resolve without job improvement or medical intervention and treatment [42]. Use of well-established workplace interventions based on sound ergonomic principles is important in reducing the risk of work-related CTS. We provided many recommendations to the poultry plant to improve work processes and reduce exposure and CTS risk among workers. Some of these recommendations included (1) designing job tasks so that levels of hand activity and force are below the ACGIH AL; (2) using additional cone lines (currently operating five) to reduce repetition for each person on the line; (3) using a job rotation schedule in which employees rotate between high- to low-risk jobs to reduce stress to specific sets of muscles and tendons; (4) encouraging early recognition and accurate reporting of symptoms; and (5) instituting a medical surveillance program for CTS to monitor employee health and determine the effectiveness of exposure prevention (monitoring injury and illness trends to identify CTS in the early stages) and medical management strategies (systematic evaluation and referral).

Conclusions

A high prevalence (34%) of poultry-processing workers with evidence of CTS was found [25]. Also, over half of participants reported hand or wrist symptoms. Moreover, 81% of the jobs we evaluated were above the ACGIH AL, and 59% were above the ACGIH TLV for hand activity and force [25]. Two large longitudinal cohort studies suggested, based on their assessment of biomechanical exposures at work, that the current ACGIH limits (AL and TLV) may not sufficiently protect some workers [36,43]. Despite automation of evisceration processes and other equipment improvements in most modern poultry-processing plants, repeated studies in this industry find a high prevalence of CTS [17,22–25]. Poultry-processing jobs continue to be hazardous with short- and long-term health consequences for the workers.

The challenge to the poultry industry is to redesign poultry-processing work to reduce risk factors for CTS and to implement guidelines for prevention, early recognition, and medical management of CTS to prevent irreversible nerve and muscle damage.

Acknowledgments

The authors are grateful for Mr. Paul Dowdy for nerve conduction testing and Dr. Albert Cook for review of the NCS results. Additional thanks go to those who provided medical and ergonomic field assistance and those who reviewed the manuscript.

Disclosure statement

We wish to confirm that there are no known conflicts of interest associated with this manuscript titled: Carpal Tunnel Syndrome Prevalence: An Evaluation of Workers at a Raw Poultry Processing Plant and there has been no significant financial support for this work that could have influenced its outcome.

Funding

We confirm that this study was funded by the Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

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Disclaimer

The findings and conclusions in this article are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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