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Lamb boning — an occupational cause of carpal tunnel syndrome?

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Abstract
Whether an occupation can cause carpal tunnel syndrome requiring carpal tunnel decompression (CTD) is contentious. We compared the demographics and incidence rates in lamb-freezing workers with the general population who had CTD. In the general population there were 1002 (63%) females and 583 (37%) males, mean age 48 years, and the rate of CTD was 1.36/1000 per annum. In lamb-freezing workers there were 225 males (mean age 38.4 years) and 60 females (mean age 44.6 years); most workers required CTD in their first three seasons. Compared with the general population, the incidence rate ratios in all freezing workers was 16.8; boners, 51.6; meat packers, 22.8; and slaughtermen, 5.4. All groups had a greater rate of CTD than the general population. This study suggests that carpal tunnel syndrome can be directly caused by an occupation.

Keywords
Carpal tunnel syndrome, incidence, occupation

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Introduction

Current opinion is divided as to whether carpal tunnel syndrome (CTS) can be caused by an occupation. It has been suggested that for an occupation to be causative the work should be forceful, repetitive, and involve extreme flexion and extension of the wrist (Hagberg et al., 1992; Palmer et al., 2007; Silverstein et al., 1987). A cold environment is also thought to play a role (Falkiner and Myers, 2002; Yagev et al., 2007). Slaughterhouse workers and boners who perform repetitive, highly strenuous work in a refrigerated environment may be at an increased risk of developing CTS (Frost et al., 1998; Gorsche et al., 1999; Masear et al., 1986). Conversely, it is argued that CTS cannot be caused by an occupation (Stapleton, 2006).

We have observed a high incidence of CTS among staff at our local slaughterhouse and freezing works. The purpose of this study was to compare the incidence and demographics of freezing workers who required carpal tunnel decompression (CTD) with a general population who underwent CTD in our region.

Methods

The Lamb Freezing Works in the southern part of our region is the largest and busiest lamb slaughter and processing plant in the world. It employs approximately 1550 workers each season, and in the 2007/8 season more than 4 million lambs were processed. Each season lasts for 6–8 months and consists of a 5 day week. A standard shift is 8.25 h plus half-an-hour for lunch and a 15 minute break in the morning and afternoon. At peak times the length of shift is increased by another hour. Lambs are killed and offal is removed by slaughtermen; each has a specific repetitive role using a knife. The bones are then removed by lamb boners using a knife in the dominant hand and a gauntlet in the nondominant hand to hold the meat. This is the most demanding job in the plant in terms of high-speed dextrous work with forcible gripping and rapid repetitive movements. After boning the meat is packaged by meat packers. Boning and packing takes place in refrigerated conditions (< 5°C). The plant works at a set chain speed and processes eight lambs per minute. There are also auxiliary staff who do not work on the production line or in the cold.

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Table 1. Details of age, gender, incidence rate ratio (IRR) by job role of freezing worker and general population.

Population/ job	Operations	Males, n (%)	Females, n (%)	Average age at CTD, male, y	Average age at CTD, female, y	Average age at CTD, all, y	Person-years at risk	Incidence, person/ years per 1000	IRR to general population	95% CI
General population (20–65 y)	1585	583 (37)	1002 (63)	47.9	48.1	48.0	1 163 520	1.36	NA	NA
All freezing workers	285	225 (79)	60 (21)	38.4	44.6	39.7	12 440	22.9	16.8	14.8–19.1
Production line workers	285	225 (79)	60 (21)	38.4	44.6	39.7	8235	34.6	25.4	22.3–28.8
Slaughter men	17	15 (88)	2 (11)	36.3	36.5	36.4	2320	7.3	5.4	3.1–8.6
Packers	133	79 (59)	54 (41)	45.4	45.5	45.5	4280	31.1	22.8	19.0–27.2
Boners	135	131 (97)	4 (3)	34.5	36.8	34.5	1920	70.3	51.6	43.0–61.6

All workers, including auxiliary staff, have equal-opportunity access to the on-site medical department and undergo a pre-employment medical evaluation. No employee had clinical features of CTS before commencing work. Those workers who develop CTS frequently describe waking with severe symptoms requiring the application of ice to the wrist for at least an hour prior to returning to the work. The diagnostic, care, and return-to-work rehabilitation pathway for CTS is described in a previous paper (Wyatt and Veale, 2008). It is our practice to obtain nerve conduction studies prior to CTD (Townsend et al., 2005).

Over eight seasons (2000/1 to 2007/8) 285 workers underwent CTD. None of the workers had any pre-existing medical conditions associated with the development of CTS. The neurophysiologist performed conduction tests at a mean of 15 days from referral (range 2–31 days). The senior author reviewed the patients at an average of 36 days from GP referral (range 7–64 days). The mean waiting time for surgery from the surgeon's out-patient appointment was 21 (range 7–42) days.

We gathered data on roles, gender, age, and exposure periods of all workers who had undergone CTD. As a control group, we collected data on all 1585 patients of working age (20–65 years) who underwent CTS in the northern part of our region over the 10 year period (2000 to 2009). The same neurophysiologist performed neurophysiological testing for both the freezing-worker population and our general population. Census data from the national census (2006) was used to determine the total population of the region aged 20–65 years. During this 10 year period, we had no significant constraints to access for CTD, as most cases were done under local anaesthesia as an out-patient procedure.

Statistical analysis was performed with the help of a medical statistician using the Stata 11 package (StataCorp LP, College Station, Texas, USA). Incidence rate ratios (IRR) with 95% CIs were calculated between groups. It was assumed that no workers had had a CTD prior to starting employment at the plant and that they remained at risk despite having surgery. This gives a conservative estimate of the rate and compensates for the fact that there was up to a 10% turnover of staff per season.

Results

Over the 10 year period (2000 to 2009) we performed CTD on 1585 patients age 20–65 years from the total population in our region of 116 352 of this age. There were 1002 females (63%) and 583 males (37%). Mean age was 48.1 years for females and 47.9 years for males (NS). The intervention rate was 1.36/1000 per annum in all patients aged 20–65 years, 1.7/1000 for women, and 1.02/1000 in men. There were 99 CTDs performed in 12 483 males aged 30–39 years; an incidence rate of 0.8/1000 per annum in this group.

In the freezing-worker, 285 workers underwent CTD; there were 225 males (79%) and 60 females (21%). Females comprised only 6 of 152 (4%) boners and slaughtermen having a CTD, but 54 of 133 (41%) packers who required surgery. At time of surgery, lamb boners and slaughtermen were significantly younger than meat packers (mean age 34.5 vs 45.5 years, respectively; $p < 0.05$) (Table 1).

There were an average of 36 workers (range 20–49) who required CTD per season and intervention rate remained relatively constant in any given season (Figure 1). In the first 4 years of the study, 129 patients underwent surgery compared with 157 patients in the latter 4 years (chi-square, $p = 0.003$). Figure 2 shows

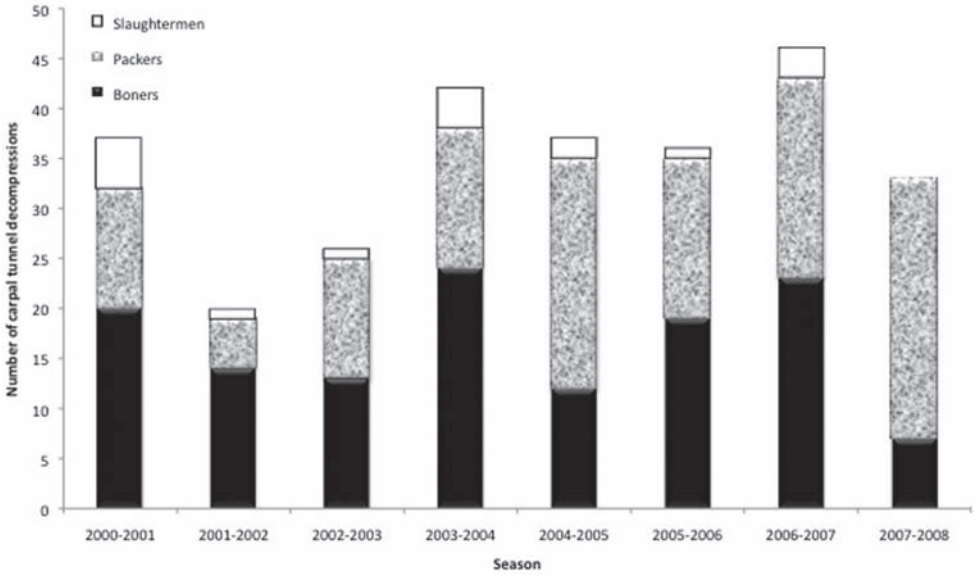

Figure 1. Proportions of lamb worker roles vs number of carpal tunnel decompressions per season.

that of those workers who underwent CTD, 73% of boners, 59% of slaughtermen, and 49% of packers were in their first three seasons of working at the plant; i.e., they required decompression early on in their careers. Workers who had CTD after five seasons had all commenced employment prior to the introduction of a care pathway described in our previous study (Wyatt and Veale, 2008).

The incidence of carpal tunnel decompression in all plant workers was 16.8 times that of the general population. When broken down by specific role, the incidence of CTS in lamb boners was 70.3/1000 (person–seasons), which was approximately twice that of meat packers (31.1/1000 person–seasons, IRR 2.3), and almost 10 times that of slaughtermen (7.3/1000 person–seasons, IRR 9.6). Packers had a 4-fold increased incidence compared with slaughtermen (IRR 4.2). No auxiliary staff underwent CTD in 8 years; therefore, IRRs to this group could not be calculated. The incidence of CTD in lamb boners was 51.7 times and meat packers 22.9 times greater than that of the general population, while slaughtermen who work with knives but not in the cold had a rate of CTD that was 5.4 times higher; all these differences were highly significant (Table 1). Despite having equal access to medical facilities, auxiliary workers had a rate lower carpal tunnel decompression than expected compared with the general population ($p = 0.02$).

Discussion

CTS is most commonly thought of as a condition that affects middle-aged females, and there has been much debate about whether CTS can be caused by work (Table 2). Phalen (1972) stated that patients with CTS usually will aggravate their symptoms with strenuous use of the hands, but occupational trauma is seldom the initiating factor. Falkiner and Myers (2002) concluded that CTS was multifactorial and, although work may be the final straw, it was less likely than demographic and disease-related variables to cause CTS. However, work in a very cold environment, possibly in conjunction with load and repetition such as butchery, may be an exception. The most recent review (Lozano-Calderon et al., 2008) of 117 studies concluded that the aetiology of CTS is largely structural, genetic, and biological, with environmental and occupational factors such as repetitive hand use playing a minor and more debatable role.

Certain occupations or activities appear to have a higher risk of developing CTS. These include butchers, grocery store workers, frozen food factory workers, meat and food processing machine operators, and platers (Hagberg et al., 1992; Roquelaire et al., 2008).

Meat and slaughterhouse workers may be particularly prone to developing CTS due to the hard repetitive nature of boning and low temperatures at which they work (Frost et al., 1998; Gorsche et al., 1999; Masear et al., 1986). In these studies, workers were typically male with a mean age of 30–39 years (Gorsche et al., 1999; Masear et al., 1986). At one meat packing plant, 117 (14.8%) employees had undergone CTD, with 20% of ham and picnic boners affected; all but two improved at 3 years (Masear et al., 1986). Frost et al. (1998) compared 743 slaughterhouse workers with 398 chemical factory workers. The CTS prevalence ratio was 4.9 for boners and 3.23 for non-boning jobs.

Table 2. Previous studies examining carpel tunnel syndrome (CTS) and occupation.

Author, year	Population	Diagnostic criteria	Findings	Relative risk
Silverstein 1987	14 cases in 652	Clinical	Increased prevalence with high repetition, high force (5.6%) compared with low repetition, low force (0.6%)	OR = 15
Masear 1986	117 cases of 788 workers	CTD	High rate of CTD (14.8%) in meat workers, 115 improved at mean follow-up 37 months	
Nathan 1988 (as calculated by Palmer 2007)	471	NCS	39% patients had neurophysiological abnormalities; high rate, high force vs low rate, low force	RR = 2.0
Hagberg 1992	Review of 21 studies		50–90% attributable to physical work load (e.g. repetitive forcible gripping); high risk groups included grinders, butchers, grocery store workers, frozen food factory workers, and platers	
Frost 1998	743 slaughterhouse workers, 398 chemical factory workers	Clinical, NCS in selected	Increased rate in boners (7.8%) and meat workers (5.1%) compared with chemical factory workers (1.6%); daily high velocity, high force activities risk factor for CTS	Boners PR = 4.9 Meat workers PR = 3.2
Lam and Thurston 1998	512 patients with CTD	CTD	Compared with general population, more likely to be > 55 y Obese (BMI > 30 kg/m^2) (females) Moderate manual work (females) Heavy clerical work (males)	x 2 x 6 x 2.4
Gorsche 1999, 2002	140 cases in 665 meat workers	Clinical	Higher prevalence (21%) and incidence (11/100 person–years) than general population; may respond to job restrictions	
Falkiner and Myers 2002	Review (64 articles)		Multifactorial, work less likely than demographic and disease-related variables; cold and load repetition may play a role	
Stapleton 2006	347 cases from medicolegal practice		Nothing to do with occupation	
Yagev 2007	127 patients vs 102 controls	NCS and clinical	Repetitive work Cold environment Increased BMI	OR = 2.15 OR = 3.52 OR = 1.14
Palmer 2007	Review of 38 papers		Hand-held vibratory tools, prolonged repetitive flexion, forcible grip have ≥ 2 fold increased risk of CTS	> 2 fold
Lozano-Calderon 2008	Quantitative review of 117 studies		Structural, genetic, and biological factors predominate; occupation minor, more debatable role	
Roquelaure 2008	1135 patients	NCS and clinical	Higher incidence in industry sector workers and occupations at high risk of CTS AFE 36–93% Manufacturing 42–93% Construction and blue collar 60–74% Meat and food processing machine operators 87.2%	 RR = 7.8
Mattioli 2009	8801 patients	CTD	BCW more likely than WCW in: All males 35–39-year-old males Females Housewife vs female WCW	 4.8 x 7.1 x 4.2 x 3.8 x
Barcenilla 2012	Meta-analysis of 37 studies	NCS and clinical	Vibration Hand force Repetition	OR = 5.4 OR = 4.23 OR = 2.26

AFE = attributable risk fraction of exposed workers; BCW = blue collar worker; BMI = body mass index; CTD = carpal tunnel decompression; CTS = carpal tunnel syndrome; OR = odds ratio; PR = prevalence ratio; RR = relative risk; WCW = white collar worker.

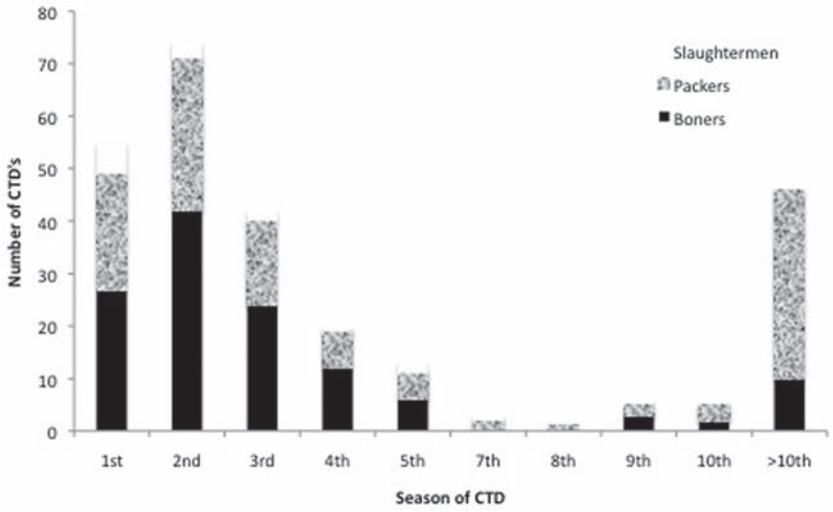

Figure 2. Number of seasons worked prior to carpal tunnel decompression for each freezing-worker role.

Gorsche et al. (1999) reported a prevalence of 21% and incidence of 11/100 person–years for clinically diagnosed CTS among 665 meat factory employees. In a follow-up study they concluded that CTS in meat packers is transient and responsive to conservative measures (Gorsche et al., 2002).

There was a significantly higher rate of CTD in our freezing worker population than both the general population control group of working age and auxiliary workers at the plant who did not work in the cold or have forceful, highly repetitive jobs. In the general population, 63% of patients were female and the mean age was 48 years. In contrast, the freezing-worker population who underwent CTD was significantly younger and mainly male. In particular, boners and slaughtermen were almost exclusively male and an average age of 34.5 years. The packers more closely matched the general population, 41% of whom were female of a mean age of 45.5 years. As no cases of CTD were performed in auxiliary workers, we used the annual incidence rate of the general population of working age (1.36/1000) to calculate IRRs. This is similar to the rate of 0.46/1000 (males) and 2.5/1000 (females) reported by Mattiololi et al. (2009). The annual incidence of CTD in our general population for males aged 30–39 years was only 0.8/1000. If this baseline rate is used, the IRR for male boners rises from 52 to approximately 88.

The precise mechanism by which work may lead to CTS is unclear. Phalen (1972) thought that thickening of the flexor synovialis may be caused by prolonged forceful grasping movements. Prolonged and highly repetitive flexion or extension of the wrist (e.g. every 30 s or less for > 20 h/week) allied with a forceful grip may increase the risk of CTS by 2–4 times (Palmer et al., 2007; Yagev et al., 2007) and cold by 3.5 times (Yagev et al., 2007). Tenosynovitis-induced fibrosis of the subsynovial connective tissue has been purported as a causative mechanism of CTS (Ettema et al., 2007). The benefit of nonsteroidal anti-inflammatories, splinting, and application of ice in our study population is in accordance with this mechanism.

In our series, it appears that the highly repetitive forcible work using both the knife and a gauntlet for forcible gripping in cold conditions leads to a very high incidence of CTS in boners. Slaughtermen working in a warmer environment with knives, but with a less-intense role, have an incidence one-tenth that of boners. Packers who work in the cold and have a repetitive job that may also include heavy lifting have an intermediate rate. The rate of requiring decompression over time for each of these roles also suggests knife-work as a causative factor (Figure 2).

Prevention strategies exist at the plant: a new lamb boner is tutored by a senior lamb boner in the requisite knife techniques, including sharpening, having a relatively loose grip, and not fouling the blade by striking the bone directly. Amongst lamb boners there is a belief that such techniques may diminish the risk of developing CTS. Boners are most likely to require CTD in their second or third season, suggesting that as they increase speed their symptoms worsen. Symptoms decrease during the off-season and return with the challenge of the new season. A more structured preventative exercise programme, such as that described by the American Academy of Orthopaedic Surgeons, may prove beneficial (Seradge et al., 2000).

Our study has a number of weaknesses. It is not a prospective cohort study. Staff turnover will have led to a greater number of employees exposed to the risk of developing CTS. However, approximately 10% of boners underwent CTD each season, and these were not removed from the 'at-risk' denominator. Other workers may have developed symptoms of CTS that led to them change employment rather than undergo CTD. Therefore, we believe that the IRR is conservative. In other studies, CTS was diagnosed using clinical examination alone or in conjunction with neurophysiological studies; this would be expected to give a higher rate of CTS. All our patients had neurophysiological studies and we have used CTD as our endpoint. The issue of workers compensation was discussed in our previous paper (Wyatt and Veale, 2008). As sickness compensation is capped at 80% in our country, there is a considerable financial incentive to return to work.

The IRR of CTS requiring decompression for lamb boners was 52 times; meat packers, 23 times, and slaughtermen, 5 times that of the general population of working age. This study provides evidence that CTS can be caused by vigorous and highly dextrous work in a cold environment.

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Conflict of interests

Both the senior surgeon and general practitioner are funded through the Accident Compensation Corporation Scheme for any care provided to patients at the Freezing Works. We acknowledge this as a potential conflict of interest.

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