

## Research Article

# Obesity and Its Relationship with Occupational Injury in the Canadian Workforce

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**Objectives.** To examine associations between obesity and occupational injury. **Methods.** Participants consisted of a representative sample of 7,678 adult Canadian workers. Participants were placed into normal weight, overweight, and obese categories based on their body mass index. Different injury types, location, and external causes were measured. Logistic regression was used to estimate relationships. **Results.** By comparison to normal weight workers, obese workers were more likely to report any occupational injuries (odds ratio (OR) 1.40, 95% confidence interval (CI): 0.98–1.99) and serious occupational injuries (1.49, 0.99–2.26). These relationships were more pronounced for sprains and strains (1.80, 1.04–3.11), injuries to the lower limbs (2.14, 1.12–4.11) or torso (2.36, 1.13–4.93), and injuries due to falls (2.10, 0.86–5.10) or overexertion (2.08, 0.96–4.50). Female workers, workers  $\geq 40$  years, and workers employed in sedentary occupations were particularly vulnerable. Increased risks were not identified for overweight workers. **Conclusions.** Obese workers experienced 40–49% higher risks for occupational injury.

## 1. Introduction

Obesity is a leading public health problem and an obvious health research priority. In our own country of Canada, one in four adults are obese, six in ten are overweight or obese, and rates of childhood obesity have tripled over the past 25 years [1, 2]. Health consequences of obesity require focused study to fully understand its societal impact. The influence of obesity on the occurrence of chronic diseases such as cardiovascular disease and type 2 diabetes are well established [3–5]. There are also a number of acute health outcomes associated with obesity that remain unappreciated. One such outcome is unintentional injury.

Links between obesity and injury, particularly injuries occurring in occupational settings, are of direct societal interest. The economic burden of obesity in Canada is estimated at more than \$4 billion annually; much of this figure is attributable to lost productivity due to worker absenteeism [6]. A number of studies have examined the association between obesity and injuries occurring within the occupational setting [7–10]. These studies report that obese persons are 26–107% more likely to have had an occupational injury

than their normal weight counterparts. However, existing studies are limited in terms of the cross-sectional designs employed, small sample sizes (i.e., <3000 participants), the narrow breadth of the workforce studied (i.e., material handlers, firefighters, and aluminum manufacturers), and the lack of consideration of different injury types and locations.

We therefore developed a national longitudinal study that aimed to quantify the associations between obesity and the occurrence of occupational injury in Canada. Through this research, we hoped for further understanding of the health impacts of obesity that in turn might inform the development and targeting of interventions aimed at the prevention of injury in occupational settings.

## 2. Participants and Methods

**2.1. Theoretical Framework.** Much of the existing literature that examines the link between obesity and injury lacks a theoretical base. To address this shortcoming, we previously developed a biophysical framework [11]. Based on existing evidence, this framework established that obesity is associated with (1) a number of risk factors for unintentional

injury (increased comorbidities [12], increased use of psychotropic medications [13], altered gait and balance [14], increased forces involved in falls, lower neural sensitivity [15], greater extremity friction [16], and sleep apnea and fatigue [17]) as well as (2) some protective factors that will help prevent injury (greater bone density [18] and increased cushioning during falls from excess fat). We hypothesized that, for many occupational injury types, the risk factors will outweigh the protective factors, resulting in an increased injury risk in obese and perhaps overweight individuals.

**2.2. Study Population.** The National Population Health Survey (NPHS) is a nationally representative, longitudinal survey conducted every two years across Canada beginning in June, 1994 [19]. The NPHS covers household and institutional residents in all provinces and territories, except persons living on Indian reserves, on Canadian Forces bases, and in some remote areas. It consists of a detailed home or telephone interview and requests information on disability, diseases, injuries, mental health, and well-being. The cohort used in this analysis consisted of adults (aged  $\geq 18$  years) in the workforce as determined by the question “*Have you worked for pay or profit at any time in the past 12 months?*”. In addition, participants had to have a recorded body mass index (BMI) in the 1998 cycle and responded to the injury questions in the 2000 cycle. The 1998 cycle was chosen as the baseline due to the lack of comprehensive injury data collected prior to the 2000 cycle. This study therefore consisted of a longitudinal analysis that examined how BMI status in 1998 predicted reports of occupational injury in 2000 within the working population.

**2.3. Overweight and Obesity.** Body mass index (BMI = weight/height<sup>2</sup>), which is the most commonly used indicator of obesity, was calculated based on self-reported weight and height. As BMI determined from self-reported height and weight is significantly lower than BMI determined from measured values, self-reported BMI was corrected to reflect measured values using the following formulas for men (BMI<sub>(measured)</sub> =  $-1.08 + 1.08$  BMI<sub>(self-reported)</sub>) and women (BMI<sub>(measured)</sub> =  $-0.12 + 1.05$  BMI<sub>(self-reported)</sub>) [20]. Standard BMI thresholds were used to create normal weight (18.5–24.9 kg/m<sup>2</sup>), overweight (25–29.9 kg/m<sup>2</sup>), and obese ( $\geq 30$  kg/m<sup>2</sup>) BMI categories [21, 22]. Underweight individuals ( $\leq 18.49$  kg/m<sup>2</sup>), who represented 1.7% of the study sample, were excluded because the mechanisms linking a low weight to injury are different from the mechanisms that link excessive weight to injury.

**2.4. Occupational Injury.** Participants in the workforce were asked to list injuries that had occurred in the past 12 months that were serious enough to limit their normal activities. A series of follow-up questions were then asked, for the most serious injury, for those who reported having at least one injury. For the purposes of this study, respondents were considered to have occupational injuries if the answer to question “*What type of activity were you doing when you were injured?*” was “*Working at a job or business (include travel to or*

*from work).*” The injury was determined to be serious if the participant claimed to have received medical attention from a health professional for their injury within 48 hours.

Injured participants were asked to report the type of injury; possible response options were *multiple injuries, fractured bones, dislocations, sprains/strains, burn/scalds, cuts, scrape/bruise/blister, brain injury, and other*. Fractured bones and dislocation were combined together for analyses. Outside of fractures/dislocations and sprains/strains, the occurrence of the other injury types were too infrequent (<0.4%) to consider in the analyses. Participants were also asked to report the locations of their injury; possible response options were *multiple locations, eyes, head, neck, shoulder, elbow, wrist, hand, hip, thigh, knee, ankle, upper back or spine, lower back or spine, chest, abdomen, and pelvis*. For the analyses, these were grouped into the following categories: upper limbs (*shoulder, upper arm, elbow, lower arm, wrist, and hand*), lower limbs (*hip, thigh, knee, lower leg, ankle, and foot*), and torso (*upper back or spine, lower back or spine, chest, abdomen, and pelvis*). The incidences of injuries outside of these 3 regions were too infrequent to be considered in the analyses. Finally, injured participants were also asked if the injury was the result of a fall, and if not, what caused the injury. The latter question was used to assess whether the injury was the result of accidental contact or overexertion.

**2.5. Confounding Variables.** Based on past research and theoretical considerations, an array of potential confounders was included in the analyses: sex, age, type of occupation, race/ethnicity, smoking status, alcohol intake, income, education, and medical conditions. Age was considered as a continuous variable in most analyses; for stratified analyses, age was also considered as a categorical variable based on an approximate even split of the sample below and above  $\geq 40$  years of age. Occupations were grouped into either *sedentary* (e.g., secretary, writer, and accountant), *moderately active* (e.g., nurse, retail salesperson, and flight attendant), or *labour intensive* (e.g., carpenter, commercial diver, and sawmill machine operator) from a more generalized list of 25 groups based on the 1991 Standard Occupational Classification [23]. Ethnicity was categorized in two groups (white and other). Alcohol intake was calculated based on the number of drinks consumed in the week prior to the interview and classified as nondrinkers (0 drinks), moderate drinkers (1 to 7 drinks), or heavy drinkers (8 or more drinks). Participants were considered current smokers if they smoked cigarettes at the time of the survey, former smokers if they were not currently smoking but had smoked more than 100 cigarettes in their life, and nonsmokers if they smoked less than this amount. Chronic medical conditions (comorbidities) were considered for inclusion; however, the incidence of these chronic conditions was too low to be considered during the modeling process.

**2.6. Statistical Analysis.** Conventional descriptive statistics were used to describe the characteristics of the study sample. Associations between BMI categories with occupational injuries (*overall, serious, specific locations, specific types, and specific causes*) were investigated using logistic

regression analyses that were adjusted for sex, age, smoking, race/ethnicity, alcohol, income, education, and type of occupation. Stratified regression analyses were also performed according to sex, age group (<40 versus  $\geq$ 40 years), and type of occupation. Sample weights were used for all analyses, and bootstrapping was used to determine the 95% confidence intervals. Population attributable risk (PAR) statistics were estimated based upon the observed prevalence of obesity in the participating Canadian workforce, and the estimated risks for occupational then serious occupational injury were observed. Analyses were performed using SAS version 9.1 (SAS Inc., Carry, NC, USA) and were powered to detect an effect size (OR) of 1.5 or more for *obese* versus *normal weight* participants, based upon baseline prevalence values and an alpha of 0.05.

### 3. Results

Characteristics of the Canadian workforce population who participated in the 1998 and 2000 cycles of the NPHS are described in Table 1. More than half of the participants were male, less than 40 years of age, employed in sedentary occupations, and either overweight or obese. Within the 12 months prior to completing the 2000 survey, 3.6% of the participants suffered an occupational injury. Sprains and strains was the most frequent type of injury, the lower limb was the most common injury location, and accidental contact was the most frequent cause of the injuries.

Table 2 summarizes the estimated effects of overweight and obesity on the occurrence of occupational injury in Canadian workers. Obesity was associated with an approximately 1.5-fold increase in the adjusted relative odds of serious occupational injury; much of this increase was attributable to specific types, anatomical sites, and external causes of injury. In particular, obesity was associated with increased odds of sprains and strains, injuries to the torso and lower limbs, falls, and overexertion injuries. Relationships between overweight and occupational injury were less consistent, with only one type of injury (injuries to the torso) associated with overweight BMI status.

Table 3 presents further analyses stratified by gender, age group, and type of occupation. The effects of BMI status on injury were most pronounced for women, workers  $\geq$ 40 years of age, and workers employed in sedentary occupations. This was observed for both *occupational injury* and *serious occupation injury* outcomes.

PAR estimates, which were calculated based upon the adjusted risk estimates and observed prevalence of obesity, were 8% for any occupational injury and 10% for serious occupational injury within the entire cohort. The corresponding PAR estimates were 16% for each type of injury among female workers, 19% and 15%, respectively, among workers  $\geq$ 40 years old, and 15% and 17%, respectively, among those employed in sedentary occupations.

### 4. Discussion

The primary finding of this national Canadian study was that obese workers experienced injury risks that were

TABLE 1: Description characteristics of workforce within the 1998–2000 National Population Health Survey ( $N = 7,678$ ).

Variable	Prevalence (%)
Gender, % men	56.1
Race, % white	89.9
Age	
<40 y	51.8
$\geq$ 40 y	48.2
BMI	
Normal	39.0
Overweight	40.0
Obese	21.0
Alcohol consumption	
Nondrinker	30.6
Light drinker	38.7
Heavy drinker	16.4
No response	14.3
Smoking status	
Smoker	30.3
Former smoker	26.0
Nonsmoker	43.7
Family income	
Low	6.4
Low-moderate	20.5
Moderate-high	39.0
High	28.2
Not reported	5.9
Type of occupation	
Sedentary	53.3
Some activity	20.6
Labour intensive	26.1
Occupational injuries	
Any injury	3.6
Serious injuries	2.7
Type of injury	
Broken bone/fracture	0.5
Sprain/strain	1.5
Location of injury	
Upper limb	1.1
Lower limb	1.2
Torso	0.7
Cause of injury	
Fall	0.8
Overexertion	0.7
Contact	1.5

approximately 40–49% higher than their normal weight counterparts. More substantial elevations in the risks of injury associated with obesity were observed among women, workers over the age of 40, and workers employed in sedentary occupations. External causes of injury that accounted for these differences in risk included overexertion injuries and falls, typically resulting in injuries to the torso (lower

TABLE 2: Associations between BMI status and different types, anatomical sites, and causes of occupational injury, 1998–2000 National Population Health Survey ( $N = 7,678$ ).

	Normal weight (39.0%)	Overweight (40.0%)	Obese (21.0%)
Any occupational injury	1.00	1.00 (0.72–1.40)	1.40 (0.98–1.99)
Serious occupational injury	1.00	1.10 (0.73–1.65)	1.49 (0.99–2.26)
Type			
Broken bone or dislocation	1.00	0.86 (0.12–6.16)	1.44 (0.52–3.99)
Sprain or strain	1.00	1.20 (0.74–1.97)	1.80 (1.04–3.11)
Anatomical site			
Upper limb	1.00	0.51 (0.28–0.91)	0.75 (0.40–1.40)
Lower limb	1.00	1.03 (0.50–2.11)	2.14 (1.12–4.11)
Torso	1.00	2.39 (1.26–4.54)	2.36 (1.13–4.93)
External Cause			
Fall	1.00	1.61 (0.67–3.91)	2.10 (0.86–5.10)
Overexertion	1.00	0.74 (0.35–1.57)	2.08 (0.96–4.50)
Contact	1.00	0.75 (0.45–1.25)	0.77 (0.41–1.44)

Data presented as odds ratios (95% confidence intervals). Odds ratios adjusted for age, gender, ethnicity, income, education, smoking, alcohol, and type of occupation.

TABLE 3: Associations between BMI status and occupational injury in subgroups of the 1998–2000 National Population Health Survey ( $N = 7,678$ ).

	Any occupational injury			Serious occupational injury		
	Normal weight	Overweight	Obese	Normal weight	Overweight	Obese
By sex:						
Males	1.00	0.99 (0.66–1.50)	1.13 (0.71–1.79)	1.00	1.02 (0.63–1.67)	1.24 (0.71–2.18)
Females	1.00	0.91 (0.47–1.76)	2.01 (1.11–3.64)	1.00	1.15 (0.55–2.14)	2.02 (0.97–4.20)
By age:						
<40	1.00	0.83 (0.53–1.30)	1.15 (0.70–1.88)	1.00	1.00 (0.57–1.74)	1.33 (0.73–2.45)
≥40	1.00	1.40 (0.83–2.35)	1.96 (1.11–3.47)	1.00	1.24 (0.68–2.26)	1.69 (0.87–3.26)
By occupation:						
Sedentary	1.00	1.05 (0.64–1.71)	1.88 (1.06–3.34)	1.00	1.16 (0.65–2.08)	2.05 (1.06–3.98)
Moderately active	1.00	1.06 (0.43–2.62)	1.22 (0.50–3.00)	1.00	1.44 (0.46–4.56)	1.13 (0.37–3.44)
Labour intensive	1.00	0.87 (0.51–1.49)	1.02 (0.57–1.81)	1.00	0.86 (0.44–1.66)	1.08 (0.52–2.25)

Data presented as odds ratios (95% confidence intervals). Odds ratios were adjusted for age, gender, ethnicity, income, education, smoking, alcohol, and type of occupation, as appropriate.

back) and lower limbs. Up to 19% of the observed risks for occupational injury were attributable to obesity within high-risk subgroups of the working population.

Our findings were consistent with many aspects of our previously developed biophysical framework which provided a theoretical base for our analyses [11]. In that framework, it was suggested that obesity includes a combination of risk and protective factors that would lead to varying risks for specific external causes of injury, including falls and sprains and strains. Major protective factors involved are increased bone density and cushioning from fat, and indeed this may have translated into some minimization of risk for fractures, as evident in the lack of association between obesity and broken bones/dislocations. Major risk factors involved include direct and indirect physical effects of obesity and its treatment including walking and balance problems, lower neural sensitivity, the psychotropic effects of some medications, and the sleepiness and fatigue attributable to

sleep apnoea. These conditions would be expected to lead to injury patterns consistent with the effects observed here for women, sedentary workers, and older workers. Our failure to identify such associations for male and younger workers, however, suggests that the theory underlying this biophysical framework may not apply equally to all members of the working population. Further, the lack of any consistent associations between overweight status and injury suggests that a threshold may exist whereby only those workers with the highest BMI values are vulnerable. At this stage and consistent with past findings [11], this framework should be applied with caution to future studies that examine the obesity-injury relationship.

Of the existing occupational studies that examine relationships between obesity and injury, most are limited in scope and size and are cross-sectional in design (e.g., [7–10]). A notable exception is the retrospective cohort study of 11,728 health care and university employees conducted

by Ostbye and colleagues [24]. Within that study, there was a linear relationship between BMI and the rate of workers' compensation claims attributable to injury. Workers with class I obesity (BMI 30–34.9 kg/m<sup>2</sup>) had 8.8 claims per 100 full-time equivalents compared to 5.8 claims for workers with a normal BMI. Collectively, the findings from previous studies suggest a modest increase in risk for injury associated with obesity. Consistent with our findings, previous studies have suggested that the risks associated with obesity differ depending on the type of injury [7, 24], site of injury [7, 24], and mechanism of injury [24]. This suggests a need to study the specific aetiologies of a variety of injury types and demographic subgroups, as well as different natures and mechanisms of injury, to fully understand the etiological relation between obesity and occupational injury risk.

The implications of our study findings for workplace health policy warrant comment. If the relationships under study are accurate and causal in nature, the PAR estimates indicate that approximately one in ten occupational injury events in the Canadian workforce are directly attributable to obesity, with up to one in five occupational injuries being attributable to obesity in susceptible population subgroups. We are unaware of previous studies that have attempted to estimate PAR estimates for workplace injury attributable to obesity. These PAR estimates are of substantial importance given the high frequency and costs of occupational injuries. In Canada, from 1996 to 2005, an average of almost one million time-loss injury claims were reported each year by provincial or territorial Worker's Compensation Boards; on average, 366,459 of these were accepted for compensation [25]. The annual cost of occupational injuries to the Canadian economy has been estimated to be over \$13.5 billion [25].

There are two primary avenues by which employers could help reduce the burden obesity has on occupational injury. First, employers should consider how obesity impacts and interacts with other salient and modifiable risk factors for workplace injury such as job and task design, physical environments, and social factors. For example, workstations can be designed to be ergonomically sound for heavier persons and not just the average person. Second, employers should consider adopting or expanding workplace wellness initiatives aimed at improving physical activity and eating behaviours in their workforce. At present, only a small percentage of Canadian employers incorporate comprehensive workplace wellness initiatives, perhaps because they do not see these initiatives as being good for the bottom line [26]. Although the medical services associated with workplace injury in Canada are covered by our public health care system and not the employer or its insurance provider, employers need to recognize that investments into workplace wellness initiatives could still have a favourable impact on the bottom line by reducing absenteeism and lost productivity.

Our study builds upon noted gaps in the literature. It was large, nationally representative, longitudinal in design, provides estimates for specific types and external causes of injury, examined subgroups of the population that appear to be particularly vulnerable, and the etiological analyses were theory driven. Noted limitations of our study include

exposure and outcome misclassification that is typical of all surveys that rely upon self-report measures. Because this was a general health survey without stated hypotheses, the latter would be expected to bias observed risk estimates toward no effect. The study was also limited by our inability to produce stable estimates of effect for specific types of injury (e.g., fractures and dislocations to lower limbs; strains and sprains to the lower back) within population subgroups due to sample size constraints. Furthermore, as the number of participants with a BMI  $\geq 35$  kg/m<sup>2</sup> (class II or III obesity) was small, we were unable to examine injury risks at the most extreme levels of obesity. Finally, our study relied on BMI as the measure of obesity. Other measures of obesity, such as the waist circumference, tend to be more strongly related to obesity-related health outcomes [27].

## 5. Conclusions

This national study points to the potential importance of obesity in the aetiology of occupational injury. The results provide evidence of use to research communities in the obesity, injury prevention, and occupational health fields. Study findings include novel data surrounding the proportion of occupational injury attributable to obesity, as well as high-risk groups that are particularly vulnerable and hence merit attention via focused prevention efforts.

## Conflict of Interests

The authors declare that they have no conflict of interests.

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