Identifying and mitigating risks for agricultural injury associated with obesity

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Abstract

In some occupational contexts overweight and obesity have been identified as risk factors for injury. The purpose of this study was to examine this hypothesis within farm work environments and then to identify specific opportunities for environmental modification as a preventive strategy. Data on farm-related injuries, height and weight used to calculate body mass index (BMI), and demographic characteristics were from the Phase 2 baseline survey of the Saskatchewan Farm Injury Cohort; a large cross-sectional mail-based survey conducted in Saskatchewan, Canada from January through May 2013. Multivariable logistic regression was used to examine associations between BMI and injury. Injury narratives were explored qualitatively. Findings were inconsistent and differed according to gender. Among women (n = 927), having overweight (adjusted OR: 2.94; 95% CI: 1.29 to 6.70) but not obesity (1.10; 95% CI: 0.35 to 3.43) was associated with an increased odds of incurring a farm-related injury. No strong or statistically significant effects were observed for men (n = 1406) with overweight or obesity. While injury-related challenges associated with obesity have been addressed in other occupational settings via modification of the worksite, such strategies are challenging to implement in farm settings because of the diversity of work tasks and associated hazards. We conclude that the acute effects of overweight in terms of injury do require consideration in agricultural populations, but these should also be viewed with a differentiation based on gender.

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1. Introduction

Overweight and obesity are known risk factors for occupational injury (Janssen et al., 2011; Ostbye et al., 2007; Pollack et al., 2007). High prevalence levels of overweight and obesity have been reported for rural populations in Saskatchewan (Chen et al., 2009; Pickett et al., 2000; Carrivick et al., 2005). Obesity-related risks could also be addressed through modiﬁcation to machine design and configuration, cloth- ing design, ergonomic modiﬁcations, and optimization of structures and other aspects of the physical environment to reduce hazardous exposures (Helander, 2005; Pheasant and Haslegrave, 2006; Marras et al., 2000; Carrivick et al., 2005). Obesity-related risks could also be addressed through modiﬁcation to work roles and practices performed by obese workers.

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We had the opportunity to explore relationships between weight and risk for injury in a large cross-sectional analysis of farmers and their families. Our specific objectives were as follows: (1) to examine the association between body mass index (BMI) and occupational injury in a farm population known to be vulnerable to both obesity (Pickett et al., 2015) and occupational injury (Canadian Agricultural Injury Surveillance Program, 2003); and (2) through review of case injury reports involving farm people affected by overweight and obesity, to identify specific opportunities to modify the farm work environment as a preventive strategy.

2. Methods

2.1. Study design and population

This study used reports compiled in January to May, 2013 during a Phase 2 baseline cross-sectional health survey of the Saskatchewan Farm Injury Cohort (Pickett et al., 2008). In Phase 1 of this study, survey procedures in this cohort were tested via a pilot randomized trial (Day et al., 2008) and are described in detail elsewhere (Pickett et al., 2008). The Dillman total design method for mailed-based surveys was employed in both study phases (Dillman, 2000). The Phase 2 sampling frame was built by augmenting the sample that remained at the end of the Phase 1 cohort, and this included 74 rural municipalities (the 50 original plus 24 additional), selected proportionally by soil zone to provide a large and heterogeneous sample of Saskatchewan farm operations. In Phase 2, participation rates were 93% at the rural municipality level and 48% at the farm level. Questionnaires were completed by a single informant on each farm. Informed consent was indicated through completion and return of the questionnaire. The study protocol was approved by the Behavioural Research Ethics Board of the University of Saskatchewan.

2.2. Key study variables

Body mass index (BMI) values were calculated using self-reported height and weight (mass (kg)) divided by height squared (m²), and used to create non-overweight (BMI < 25 kg/m²), overweight (BMI 25–29.9 kg/m²), and obese (BMI ≥ 30 kg/m²) categories. Participants with an underweight BMI (n = 18) were included in the non-overweight study group, and for children aged 7 to 17, internationally accepted age and sex-specific thresholds were used for the three BMI categories (Cole et al., 2000).

Farm-related injuries were defined as “...injuries that occurred in a farm environment whether you were working or not. This includes injuries that occurred off-farm but involved farm work (e.g., driving a tractor on a public road). This also includes being poisoned or burned.” We asked respondents to recall injury events in the prior calendar year (2012). Additionally, for their one most serious injury, respondents provided a structured narrative that included information on what they were doing, where and how it happened, what went wrong, and the nature and anatomical site of injury experienced.

Individual level factors that were potential confounders between BMI and injury included the following: age in years, sex, relationship to the farm owner-operator (‘primary owner-operator’, ‘spouse’, ‘parent, child, or other relative’), highest level of education completed (‘less than high school’, ‘completed high school’, ‘completed post-secondary’), binge drinking as reported by the consumption of 5 or more alcoholic drinks at one sitting (‘never’, ‘at most once a month’, ‘at most once a week’, ‘more than once a week’), current smoker (‘yes’ or ‘no’), number of doctor-diagnosed comorbidities (‘0’, ‘1’, ‘2 or more’ of the following: sleep apnea, rheumatoid arthritis, osteoarthritis, high blood pressure, heart disease, diabetes, stomach or intestinal problems, asthma or other lung conditions, dementia, hearing loss, depression, chronic pain, incontinence/urinary problem), typical sleep duration (‘≥7 h’, ‘6 to 7 h’, ‘<6 h’), excessive daytime sleepiness (Epworth Sleepiness score ≥ 11) (Johns and Hocking, 1997), and hours of farm (hours per week, averaged over the full year) and off-farm work (‘part-time’ (<30 h/week), ‘full-time’ (≥30 h/week)). Sex was also examined as a potential effect modifier (Janssen et al., 2011).

Farm (area) – level factors considered as confounders included commodities produced, total farm acreage (‘0–500’, ‘501–1500’, ‘1501–2500’, ‘>2500’ acres), and farm safety conditions/practices (“Would you say the safety conditions and practices on your farm are:” ‘Excellent’, ‘Good’, ‘Fair’ or ‘Poor’). In addition, a socioeconomic index was created from three items; frequency that cash flow shortages and also debt were sources of worry on the farm (‘every day’, ‘at least once a week’, ‘at least once a month’, ‘less than once a month’, ‘never’), and farm operation income at the end of the most recent fiscal year (‘large deficit’, ‘small deficit’, ‘break even’, ‘small surplus’, ‘large surplus’). These items were internally consistent (Cronbach’s alpha = 0.82) and were summed and grouped into an overall socio-economic index that was subsequently divided into tertiles.

Work task exposures. We assessed time engaged in the following work tasks (days per year or hours per week) over the previous year: operating tractors and combines, tractor and combine maintenance, chores with large and small animals, herd maintenance and veterinary activities, lifting, lowering, or carrying heavy objects, using a shovel or pitchfork, working with hands over shoulder height, operating power tools. Origins and testing of these items is described elsewhere (Pickett et al., 2008).

2.3. Statistical analysis

SAS version 9.4 (SAS Institute, Cary, NC, 2010) was used for all analyses. Following initial descriptive analyses, multivariable logistic regression using the SAS procedure PROC GLMIMIX was utilized to examine associations between BMI categories and farm injury, adjusting for clustering by farm using a random effect statement. Guided by previous study findings (Janssen et al., 2011) we examined whether sex was an effect modifier in the association between BMI status (the primary exposure) and injury through inclusion of a two-way interaction term; subsequent modeling was then stratified by sex. Potential confounders were identified through backwards elimination (p < 0.15) and change in estimate approaches (>10%) (Rothman et al., 2008). Any covariate identified as a confounder was included in each of the sex-stratified models. The final analysis was restricted to participants with valid responses to items included in the regression models (n = 2333 (1406 males and 927 females)). For the overweight and obesity exposures this study was 80% powered to detect modest injury effects in men (OR: 1.8 to 2.0) and in women (OR: 2.1 to 3.3) at an alpha level of 0.05, 2-sided. For the other categorical exposures, the study was similarly powered to detect modest to large effects (OR 1.9 to 4.6).

Further analyses were conducted to complement the regression findings and inform prevention strategies. Time reported engaging in specific farm work tasks was examined descriptively by sex and BMI status to identify work exposure patterns. Following the quantitative analysis, we also explored qualitatively the narratives associated with individual injury events. For the subset of injuries reported by farm women, thematic coding was performed, and common themes were extracted in the areas of incident cause, work task involved, and how weight may have influenced risk. Based on the identified themes we referred to published literature and the expertise of our research team to make suggestions for common environmental or behavioural strategies that could be used to address overweight and obesity as a potential cause of farm-related injury.

3. Results

Overall, 39% (95% CI: 37% to 41%) of individuals in the farm cohort were classified with an overweight BMI, and 26% (95% CI: 24% to 28%) were classified as having obesity, with prevalence levels higher
in males than females (Table 1). Age/sex-standardized estimates for
this cohort have been described previously (Pickett et al., 2015). The
type of agricultural injuries experienced varied; the most common
were lacerations to the hands, back strains, knee and shoulder/rota-
tor cuff tears, and ankle sprains. The most common farm work tasks
performed by men were operating tractors and combines, and
performing chores with large animals. Collectively, farm women
spent the most time operating tractors, and performing large and
small animal chores.

Relationships between BMI and the occurrence of farm injury varied
between males and females (test for interaction, \( p = 0.02 \)). Important
confounders identified then adjusted for in the final models were ‘rela-
tionship to the owner-operator’ in men and ‘farm acreage’ in women.
The final models also adjusted for age and exposure to farm work in
hours.

In men, neither having overweight nor having obesity were associat-
ed with increased risk of reporting a farm injury (Table 2). In women,
after adjusting for the same set of covariates, having overweight was
significantly associated with such an increase (OR: 2.89; 95% CI: 1.30
to 6.44). Having obesity was not related to risk for injury in women.
Four common patterns of injury related to overweight and obesity
are described using illustrative vignettes.

**Pattern 1 – falls**

A 55 year old male farmer is dismounting from a combine after a
long day of working in the field. While climbing backwards down
the steps of the combine he misjudges the distance from the last
step to the ground, and rolls his ankle. The result is a bad sprain
that limits his ability to carry out normal work tasks for several
weeks.

Many of the injuries to overweight and obese farmers were the re-
sult of falls (\( n = 52 \) (34%)). Common mechanisms were falls from
large machinery, from ladders or scaffolding, and slipping on ice in the
farm worksite. The above vignette is illustrative of the pattern because
(1) it involved an obese male operator; (2) he was climbing on a ma-
chine with a known ergonomic hazard; (3) there was loss of physical
balance, probably attributable to his weight status; and (4) the resultant
injury was debilitating.

**Pattern 2 – [repetitive] manual labour tasks**

A 50 year old female farmer is pitchforking hay. After 20 minutes of
forking she “throws out” her lower back, and is unable to perform
manual tasks for several days while recovering.

| Characteristic | BMI | \( p \)-Valuea |
|---------------|-----|---------------|
|               | Non-overweight (≤ 25.0) | Overweight (25.0–29.9) | Obese (≥ 30.0) |
|               | row% | row% | row% |
| n = 832       | n = 930 | n = 611 |
| Overall       | 35   | 39   | 26   |
| Age, years    | 7–19 | 63   | 21   | 16   | \(-0.001\) |
|               | 20–44 | 44   | 34   | 22   | \(-0.001\) |
|               | 45–64 | 29   | 43   | 28   | \(-0.001\) |
|               | 65+  | 30   | 43   | 27   | \(-0.001\) |
| Sex           | Male | 26   | 45   | 29   | \(-0.001\) |
|               | Female | 49   | 30   | 21   |

Note: Data are from Phase 2 of the Saskatchewan Farm Injury Cohort
study, conducted in Saskatchewan, Canada from January through April, 2013.

a Findings from the Rao-Scott chi-square test that accounts for the nested and clustered
nature of the data.

Repetitive manual labour tasks, including shovelling and forking,
lifting calves, and operating large machinery for extended periods of
time, often resulted in injuries to the back and shoulders (\( n = 25 \)
(19%)). The vignette is illustrative of the pattern because (1) it involved
an overweight female farmer; (2) she was performing a physically de-
manding task; (3) a repetitive bending/twisting motion was involved;
(4) the task was of long duration, leading to fatigue; and (5) the injury
occurred to the lower back.

**Pattern 3 – working in close proximity to hazards**

A 58 year old female farmer is helping her neighbour “pregnancy
check” a young female cow (heifer) in a confined space. The heifer
kicks out and knocks her backwards into a metal gate. The farmer
suffers lacerations to her hands and face that require suturing.

Among overweight and obese men and women, working in close
proximity to hazards was another common mechanism of farm injury
(\( n = 29 \) (19%)). Specifically, farmers performing tasks such as working
with large animals and repairing large machinery, lacerations to the
hands and face and bruising injuries happened quite frequently. This vi-
gnette is illustrative of the pattern because (1) it involved a female
farmer with obesity; (2) she was helping with a task; (3) she was work-
ing with a large animal; and (4) there was forced proximity.

**Pattern 4 – “helper tasks” in women**

During the busiest time of year, a female spouse of a male farmer is
recruited to help fix a section of fencing. While supporting the
weight of the fence, she loses her footing, falling backwards and hit-
ting her head. The fall results in a concussion and small laceration to
the back of her head.

Of the injuries to overweight or obese women, in 4 (17%) of the in-
jury narratives it was explicitly stated that the woman was assisting
with a work task. With limited descriptive data available it is possible
this number is actually higher. The vignette is illustrative of the injury
pattern because (1) it involved an overweight female; (2) she was rec-
cruited to help with a farm task; (3) she was physically incapable and/
or overexerted herself during the task; and (4) the injury mechanism
involved compromised balitg.

4. Discussion

The most important finding of this analysis was that women with a
BMI in the overweight range were at increased risk for farm injury,
while no such effects were reported for women with obesity, nor men
with overweight or obesity. From injury narratives we also observed de-
scriptive patterns that might partially explain the observed increases in
risk reported specifically for women with an overweight BMI.

Excessive body weight has been identified as an independent risk
factor for occupational injury among women (Janssen et al., 2011).
Mechanistically, differences in fat distribution between men and
women may lead to biomechanical effects that differentially impact
how obesity influences injury risk. Men tend to deposit more fat in
their abdomen and women deposit more fat in their periphery (Power
and Schulkin, 2008). In the narratives provided for overweight
women, they frequently reported fall/sprains to the lower limbs (44%
of injuries) and manual labour-related injuries (33%), suggesting that
risk could be related to such biomechanical effects when assigned to
work in hazardous situations.

Observed sex differences may also relate to durations and types of
hazardous occupational exposures that are common in women with
an overweight BMI. These women appear to be more highly involved
on the farm than are women with an obese or non-overweight BMI.
This was true for every farm work task that was assessed. The obesity it-
self may be protective since it will naturally limit the endurance of the
individual with respect to the intensity and duration of work exposures.
From a more gendered (social) perspective, the injury narratives also indicated that these events typically occurred while “assisting” or “helping” a male farm operator operationally. If the injury events involved machinery, women assigned to such helper roles may experience elevated risk simply due to not being in the safest work location, which is being in the operating position. Heavier and less physically mobile male owner-operators may also require the most assistance. Of the women in our study who were overweight and injured, 93% (13 out of 14) had an overweight or obese male spouse. In a Phase 1 study performing routine machinery maintenance (e.g., greasing, fueling, and cleaning windows) was associated with high risk for injury (Narasimhan et al., 2010). A smaller woman would fit more easily, than a larger man, into the spaces on a machine where this work is being undertaken. Heavier and less physically mobile males affect their ability to determine whether reported injury mechanisms were specifically associated with overweight and obesity. Table 3 outlines a number of potential modifications, previously shown to be effective in reducing injury in other workplace settings that emerged from the patterns of injury observed among overweight and obese farm men and women. While offering some insights, this table points to some of the challenges that are inherent to farm work environments in terms of minimizing risks. With such diversities of hazards and ways of operating associated with the independent natures of farm businesses, it is difficult to recommend environmental modifications that are universal and yet specific to each farm work context. In addition to these specific recommendations, as another prevention approach we have recently demonstrated that adherence to the six steps in a modified hierarchy of control (HOC) has the potential to reduce injury among farm owner-operators (Dosman et al., 2015). Considering the 6 steps in the HOC of 1) hazard identification; 2) risk assessment; 3) procedural controls; 4) personal protection; 5) engineering controls; and 6) elimination of the hazard, it is possible that each of these steps might be specifically undertaken to reduce the likelihood of injury in persons with overweight or obesity undertaking farming activities, irrespective of sex.

Strengths of our research include its novelty, as well as the size and diversity of the population under study. The Saskatchewan Farm Injury Cohort represents one of the few such population health studies conducted in North America. Limitations of our research include our inability to determine whether reported injury mechanisms were specifically affected by BMI status in individual cases. Nor do we have the ability to assess overweight and obesity in large-scale mail-based studies, could be used to mitigate risks associated with overweight and obesity. Table 3 outlines a number of potential modifications, previously shown to be effective in reducing injury in other workplace settings that emerged from the patterns of injury observed among overweight and obese farm men and women. While offering some insights, this table points to some of the challenges that are inherent to farm work environments in terms of minimizing risks. With such diversities of hazards and ways of operating associated with the independent natures of farm businesses, it is difficult to recommend environmental modifications that are universal and yet specific to each farm work context.

### Table 2
Multivariable logistic regression analyses examining risk factors for farm injury in the Phase 2 Saskatchewan Farm Injury Cohort with models stratified by sex.

| Characteristic | Males (n = 1406) | Females (n = 927) |
|---------------|----------------|------------------|
|               | Total (n) | % Injured | Adjusted* OR (95% CI) | Total (n) | % Injured | Adjusted* OR (95% CI) |
| BMI           |           |          |                     |           |          |                     |
| Non-overweight | 363       | (9.9)    | 1.00                | 457       | (2.2)    | 1.00                |
| Overweight    | 636       | (11.3)   | 0.95 (0.61–1.48)    | 280       | (6.8)    | 2.94 (1.29–6.70)    |
| Obese         | 407       | (12.5)   | 1.07 (0.67–1.71)    | 190       | (2.6)    | 1.10 (0.35–3.43)    |
| Age, per 10 years | 0.06 | (0.84–1.10) | 0.91 (0.67–1.25) |           |          |                     |
| Relationship to owner |           |          |                     |           |          |                     |
| Primary owner/operator | 982 | (13.2) | 1.00                | 60       | (6.7)    | 1.00                |
| Spouse        | 59        | (11.9)   | 0.90 (0.39–2.06)    | 701       | (4.0)    | 0.59 (0.17–2.05)    |
| Parent, child, other | 365 | (6.0)   | 0.47 (0.26–0.86)    | 166       | (1.2)    | 0.17 (0.02–1.31)    |
| Farm work, per 10 h/week | 1.09 | (1.00–1.18) | 1.07 (0.88–1.28) |           |          |                     |
| Farm acreage  |           |          |                     |           |          |                     |
| 0–500         | 222       | (10.4)   | 0.82 (0.48–1.41)    | 152       | (1.3)    | 0.30 (0.06–1.44)    |
| 501–1500      | 394       | (14.0)   | 1.00                | 272       | (4.0)    | 1.00                |
| 1501–2500     | 290       | (11.4)   | 0.77 (0.48–1.25)    | 208       | (6.3)    | 1.59 (0.67–3.76)    |
| >2500         | 500       | (9.6)    | 0.64 (0.41–1.00)    | 295       | (2.7)    | 0.62 (0.23–1.63)    |

Note: Data are from Phase 2 of the Saskatchewan Farm Injury Cohort study, conducted in Saskatchewan, Canada from January through April, 2013. Statistically significant OR’s are in bold (p < 0.05).

* Adjusted for all other covariates in the table.

In conclusion, this report was designed to investigate the role, if any, of overweight and obesity in the occurrence of farm injury. Our analysis showed that overweight is a potential risk factor, but specifically in women. This observation makes sense, in that the injury narratives...
suggest that risk is inherent to the high risk, helper tasks that are often done by women with an overweight BMI. It is also possible that women may be less adapted to the mechanistic farm work environment, and therefore less likely to be able to take the physical actions required to avoid injury in high risk situations. Additionally, women may have less muscular strength than do men, and for this reason may be at enhanced risk of injury in certain situations. These findings highlight the importance of considering issues of overweight and obesity, and injury, with a differentiation based on gender on farms and on task assignments, as well as some of the challenges in providing environmental solutions that are universal and potentially efficacious.

Conflict of interest statement

No conflicts of interest to declare by any author.

Transparency document

The Transparency document associated with this article can be found in the online version.

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