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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.

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., 2015). Biological mechanisms that may underlie such effects include the influence of altered gait and balance, increased forces involved in falls, higher rates of sleep apnea and fatigue, and increased susceptibility to musculoskeletal damage due to comorbidities (e.g., osteoarthritis) (Janssen et al., 2011). Additionally, excessive body weight can create physical challenges in manual work situations. Mechanistically, these occur during lifting, bending, reaching, and pushing/pulling, and through poor mobility, reduced grip strength, and poor anthropometric fit (Jensen, 2005).

Historically, occupational interventions for overweight and obesity, such as workplace wellness programs (Osilla et al., 2012), have attempted to address physical activity and dietary behaviours in the workforce. These initiatives have had little impact on body weight over the long-term (Anderson et al., 2009). Furthermore, while behavioural-based wellness programs are practical for large workplaces, they are more challenging for small, independently operated farm operations. Obesity can be managed in the workplace by addressing the physical barriers that restrict the quantity and quality of participation in work by persons affected by obesity (Forhan and Gill, 2013). This could potentially be achieved by environmental modification to mitigate risks for occupational injury. In farm work contexts, this could include modifications to machine design and configuration, clothing 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 (m^2), and used to create non-overweight (BMI < 25 kg/m^2), overweight (BMI 25–29.9 kg/m^2), and obese (BMI ≥ 30 kg/m^2) 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 GLIMMIX 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/rotator 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 'relationship 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 associated 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 result 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 machine 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.

Table 1
BMI status of participants in the Phase 2 Saskatchewan Farm Injury Cohort.

Characteristic	BMI			*p*-Value[a]
	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 demanding 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 vignette is illustrative of the pattern because (1) it involved a female farmer with obesity; (2) she was helping with a task; (3) she was working 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 hitting 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 injury 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 recruited 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 balance.

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 descriptive 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 itself may be protective since it will naturally limit the endurance of the individual with respect to the intensity and duration of work exposures.

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[a]		Total (n)	% Injured	Adjusted[a]	
			OR	(95% CI)			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			0.96	(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	(0.02–1.33)
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 ($p < 0.05$).
[a] Adjusted for all other covariates in the table.

From a more gendered (social) perspective, the injury narratives also indicated that these events typically occurred while "assisting" or "helping" a male farm operator occupationally. 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 needs to be done. The farm workplace is traditionally a male setting and therefore set up for men ergonomically. Women with overweight likely fit into such ergonomic spaces better than women and men affected by obesity, and have more strength than women of normal weight, and therefore are often more suited to helper jobs in terms of having the required strength, endurance, and/or physique to perform the tasks.

The lack of an association between having overweight and/or obesity and injury identified for men also warrants comment. Being self-employed, farmers have some independence in their work choices. If obesity makes farmers feel uncomfortable physically, for example while operating equipment, they would often have the ability to stop work or change their work task in response to this discomfort. Indeed, past analyses with this cohort showed that farmers with obesity are differentially performing less active tasks (Pickett et al., 2015), and their risks for injury are likely less intense than others per hour of exposure. Causes and mechanisms of injury also appeared to relate to BMI status reported for men. A greater proportion of injuries to men with obesity were to the back, shoulders, hands and wrists, suggesting that obesity may be a risk-factor for particular subtypes of occupational injury as per the aforementioned biomechanical theories.

Aside from bariatric surgery, efforts to treat excess weight over the long term have had limited success; this is true for both general (Wu et al., 2009) and occupational environments (Anderson et al., 2009). Therefore, efforts around managing excess weight in the workplace need to consider modifications of occupational environments for individuals affected by overweight and obesity and not merely on attempting to get people to lose weight (Marras et al., 2000; Carrivick et al., 2005). We therefore used evidence from the injury case descriptions to explore if such modifications, primarily through workplace ergonomics (Helander, 2005; Pheasant and Haslegrave, 2006; Marras et al., 2000; Carrivick et al., 2005), 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. 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 confirm all self-reports, especially those made by proxy. A limitation of using BMI as a measure of overweight and obesity is that it does not distinguish body composition (Prentice and Jebb, 2001). Farmers with greater muscle mass may be inaccurately classified as overweight (Prentice and Jebb, 2001). However, BMI is a feasible method for assessing overweight and obesity in large-scale mail-based studies, and has been widely applied in previous settings (Shulte et al., 2007). The cross-sectional nature of our data also limits our ability to infer the temporal aspects of causation. Some of our analyses also suffered from limited statistical power due to the rarity of injury events.

5. Conclusion

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

Table 3
Occupational risks associated with injuries to overweight women on farms and researchers' suggested environmental modifications to mitigate risk.

Injury pattern	Illustrative vignette	How weight can increase risk	Suggested modifications to work environments (Helander, 2005; Pheasant and Haslegrave, 2006; Marras et al., 2000; Carrivick et al., 2005)
Falls	Pattern 1	• Compromised balance and reduced mobility • Poor anthropometric fit • Increased risk of ladder slipping • Increased forces involved in falls	• Widen stairway and steps on machinery • Enhance grip on rails and steps • Increase ladder dimensions • Use spotters • Ensure presence of safety cages on ladders • Attention to safety footwear • Keep workspace and ladders clear of debris, ice and fall hazards
Working in close proximity to hazards	Pattern 2	• Forced proximity • Reduced reaction times • Poor anthropometric fit	• Install man escapes for entry and exit • Enlarge enclosures • Ensure hazards are well secured
Repetitive manual labour tasks	Pattern 3	• Physical (ergonomic) challenges • Fatigue • Poor anthropometric fit	• Make ergonomic modifications to equipment • Minimize carrying distances • Use assistive devices • Increase seat and cab dimensions • Increase adjustability features • Incorporate breaks or task rotation
"Helper tasks" in women	Pattern 4	• Compromised balance and reduced mobility • Poor anthropometric fit • Fatigue • Reduced manual dexterity and grip strength	• Make ergonomic modifications to equipment • Use assistive devices • Avoidance of physically demanding tasks

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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