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Farmers, mechanized work, and links to obesity

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Abstract (188 words)

Objective. In a contemporary sample of Saskatchewan farm people, to relate the degree of mechanized and also non-mechanized farm work to the occurrence of being overweight or obese. Secondarily to determine the prevalence of being overweight or obese, and to compare these prevalence levels with those reported for general populations.

Method. Cross-sectional analyses of baseline survey data provided for 2,849 individuals (2,619 adults) from 1,216 Saskatchewan farms in 2013. Age/sex-standardized prevalence levels of overweight and obesity were compared between the farm cohort and general populations. Durations of specific types of work were described by metabolic equivalent scoring. Multi-level binomial regression was used to study relations between mechanized and also non-mechanized farm work with overweight and obesity.

Results. Overall, 65.1% of the adult farm cohort was overweight (39.6%) or obese (25.5%), with prevalence levels that exceeded estimated norms for Canada but not the province of Saskatchewan. Increases in risks for obesity were related to higher amounts of mechanized but not non-mechanized farm work.

Conclusion. While the mechanization of farm work has obvious benefits in terms of productivity, its potential effects on risks for overweight and obesity must be recognized.

Key Words: agriculture, epidemiology, farming, machinery, obesity, occupational health

Introduction

Farming is often depicted as a healthy occupation. When this occupation is considered in popular culture, it is easy to conjure an image of a wholesome lifestyle, with exposure to nature and the outdoors, hard physical work, a diet of natural foods, the many benefits of individual responsibility, and the avoidance of a hectic pace. Yet, a number of quiet epidemics have been recognized within agricultural populations, including physical trauma and injury (Pickett et al., 2001), poor mental health (Gregoire, 2002), suicide (Milner et al., 2013), and occupation-related respiratory disease (Kirkhorn et al., 2000). There is also evidence that people living on the farm are heavier (Brumby et al., 2013; Chen et al., 2009) and that the weight of rural dwellers has increased over the past three decades (Chen et al., 2009). Some of the more idealistic images of the health of farm populations are likely mythical.

Coincident with these facts, major technological advances in farming production have emerged. These include work that is increasingly mechanized and associated with decreases in energy expenditure (Dimitri et al., 2005). Mechanization is particularly apparent on farm operations that produce grain commodities. In the early 1900's, it took a worker a full day of hard labor to shuck 100 bushels of wheat, whereas today this work can be performed by a single combine operator in under five minutes with little physical effort (Constable and Somerville, 2003).

Mechanization, resulting in reduced energy expenditure (Dimitri et al., 2005; Laningham-Foster et al., 2003) may have adverse consequences to farmers, as sedentary occupations contribute to obesity (Choi et al., 2010; Church et al., 2011; Bonauto et al., 2014) and have been associated with chronic diseases (Must et al., 1999). Yet, the impact of occupational mechanization on obesity risk has not been studied on farms. We therefore conducted a study with the following primary objective: (1) to relate the degree of mechanized and also non-mechanized farm work to overweight and obesity. Our secondary objectives were to determine the prevalence of overweight and obesity, and to compare these prevalence levels with those reported for the general population in the province of Saskatchewan and Canada. Our hope was that such

evidence could provide foundational information to assist clinicians in health counselling efforts. More broadly, it may be important to intentionally address the role of non-occupational physical activity within groups of people with increasingly mechanized jobs.

Methods

Study design and population.

The Saskatchewan Farm Injury Cohort Study (SFIC) was developed to understand more about the health of farm populations (Pickett et al., 2008). It involved development of a diverse sample of farms in order to study relationships between individual and contextual factors and health outcomes. The present study was based on baseline data from Phase 2 of the SFIC, which was initiated in January 2013. The sample consisted of 2,849 individuals (2,619 adults) residing and/or working on 1,216 farms from 74 different rural municipalities. Participation rates were 93% at the municipality level and 48% at the farm level.

A health and operational survey was sent by mail and completed by a single informant on each farm. Information was collected about each farm resident and farm operation. The Dillman total design method for self-administered questionnaires was utilized (Dillman, 2000). Survey procedures were tested via a pilot trial (Day et al., 2008) as described elsewhere (Pickett et al., 2008). Informed consent was indicated by completion and return of the questionnaire. The study was approved by the Behavioural Research Ethics Board of the University of Saskatchewan.

Study variables

Overweight and obesity. Respondents reported each participant's weight (in pounds or kilograms) and height (in feet and inches, or cm) which were used to calculate the body mass index (BMI, kg/m^2). BMIs were separated into *non-overweight*, *overweight*, and *obese* categories using standardized thresholds for adults (<25, 25-29.9, and ≥30 kg/m^2) and age/gender specific thresholds for children aged 7 to 17 (Health Canada, 2003; Cole, 2000).

Individual-level covariates. For each participant, we obtained their sex (*male, female*); age which we categorized into four groups (*7-19, 20-44, 45-64, ≥65 years*); relationship to the farm owner-operator ("*primary owner-operator", "spouse", "parent", "child", "other relative"*); level of formal education completed ("*less than high school", "completed high school", "completed university", "technical/community college*"); reports of an off-farm occupation (*"none", "part-time", "full-time"*) (Statistics Canada, 2014); and number of reported comorbidities (*0, 1, ≥2*). We also asked about health behaviors: alcohol consumption in the previous year *(4 categories: "never"* through *"more than once a week"*) (Statistics Canada, 2013)*;* excessive daytime sleepiness (*>10 on the Epworth Sleepness Scale*) (Johns and Hocking, 1997); and current smoking status *("yes"* or *"no"*) (Statistics Canada, 2013).

Farm-level covariates. Farm factors considered were estimated total farm acreage *("≤500", "501-1500", "1501-2500", ">2500");* commodities produced (e.g,, *"beef cattle", "grains"*); worry over debt and cash flow shortages in 2012 (5 categories, *"every day"* through *"never"*) (Pickett et al., 2007); and an item describing the financial state of the farm at the end of 2012 (5 categories, *"large deficit"* through *"large surplus"*). The three socio-economic variables were combined into an internally consistent summary index (Cronbach's alpha = 0.82) and placed into *"low", "medium"* and *"high"* tertiles.

Exposures to farm work. Average reported hours of farm work per week were estimated by season and then averaged over the full year ("*none", "part-time" (<30hrs/week), "full-time" (≥30hrs/week)*). We asked respondents to estimate exposure to mechanized farm work tasks for 2012 in hours/year (*"operation of tractors", "maintenance of tractors", "operation of combines", "maintenance of combines"*) and days/year (*"operation of all-terrain vehicles", "operation of power tools with hands more than one hour over the day"*). These items were developed for our study and were subject to multiple pilot tests for face validity (Pickett et al., 2008; Day et al., 2008). Reported hours/ year were converted to days per year at an assumed

average rate of 8 hours/day. For analytical purposes, each of these variables was classified into four groups (none, plus tertiles of the remainder).

Items describing exposure to non-mechanized work included: *"lift, lower, or carry heavy objects (over 20 lbs) more than 1 hour over the day "; "using a shovel or pitchfork more than 1 hour over the day"*; *"work with hands over shoulder height more than 1 hour over the day"; "routine chores with large animals (e.g., cattle or pigs)", "routine chores with small animals"*, *"herd maintenance activities (e.g., branding, vaccinating, transporting)"*, and *"veterinary activities (e.g., medications administration, breeding, birthing)".* These items were developed for this cohort and were subject to pilot tests for face validity (Pickett et al., 2008). Each was classified into four groups (none, plus tertiles of the remainder).

We then created two additive scores, one for mechanized and one for non-mechanized farm work, to illustrate the cumulative effects of exposure. Indicator variables (1-"*yes*" vs. 0-*"no"*) were created according to whether participants were in the highest category of each of the specific work tasks. The summed additive scores varied between 0 (lowest activity) and 5 or more (highest activity) for mechanized and non-mechanized work.

The energy expenditure rates of different work tasks were expressed using metabolic equivalent (MET) scoring. MET scores refer to the ratio of the energy expenditure rate for an activity compared to resting energy expenditure. Thus, a MET of 3.0 infers that the energy expended while doing that activity is three times that of rest. MET scores were abstracted from the Compendium of Physical Activities (Ainsworth et al., 2000). The Compendium has been used extensively to assign intensity and energy expenditure units to different activities (e.g., Jetté et al., 1990).

Statistical Analyses

All analyses were conducted in SAS 9.3 (SAS Institute, Cary, NC, 2010). We first described the cohort with respect to BMI, by age group and sex. Using the age/sex demographic structure of

the 1991 Canadian population (Statistics Canada, 1991) as the standard, we estimated directly standardized prevalence values for overweight and obesity for adult farm cohort members. Age-standardized estimates for the general (farm and non-farm) adult population of Saskatchewan and Canada that participated in the 2012 Canadian Community Health Survey (CCHS) (Statistics Canada, 2012) were then presented. BMIs were calculated from self-reported height and weight in the CCHS.

We described engagement in specific farm work activities, both mechanized and non-mechanized, in days per year. We then modeled the relative risks of obesity and then overweight (referent: non-overweight) by duration of engagement in different types of farm work using multi-level binomial regression analyses. The latter accounted for clustering by family. Age and sex were forced into these models, with selection of additional covariates governed by backwards elimination processes and the change in estimate approach.

Results

Overweight and obesity. Overall, 65.1% of the adult farm cohort was overweight or obese, with age/sex-specific values as high as 82.7% among 45-64 year old males and 59.9% among females aged 65 years and older (**Table 1**). Overweight and obesity were higher among males than females and increased from childhood through adulthood. The age/sex standardized estimate of the prevalence of overweight in adults (36.7%) was higher in the farm cohort than analogous values reported in the 2012 CCHS for Saskatchewan and also Canada (Statistics Canada, 2012). For obesity, the age/sex standardized value (22.5%) for adults was higher in the farm cohort than Canadian averages, but slightly lower than the general Saskatchewan population.

A large proportion of this farm cohort reported no engagement in the mechanized and non-mechanized farm tasks examined (**Table 2**). For those who did engage, more days were spent doing mechanized tasks than non-mechanized tasks. These mechanized tasks have energy

expenditure rates that are lower than for the non-mechanized tasks (MET range of 2.8-4.0 versus 3.0-8.0)

Associations between farm work tasks and reports of overweight and obesity were very consistent (**Table 3**). Modest increases in risks for overweight and obesity were noted with increasing relative levels of each of the mechanized farm work tasks. Conversely, the non-mechanized farm work tasks were inconsistently associated with overweight or obesity. These models were adjusted for age, sex, and socio-economic status; following backwards elimination and change of estimate methods, all other risk factors were eliminated from the models.

These associations are further illustrated in **Figure 1**. As the level of participation in mechanized farm work tasks increased, so did the reported presence of overweight and obesity (P-trend for overweight = .003, P-trend for obesity = .001). No consistent trends were observed between level of participation in non-mechanized work activities and the two BMI categories (P-trend for overweight = .78, P-trend for obesity = .89). The ICC for individuals within the same family was .13 for level of mechanization and obesity, and .07 for level of mechanization and overweight.

Discussion

A large proportion of farmers examined were overweight or obese. The prevalence of overweight and obesity were slightly higher for farm people than that of values reported for the Canadian population. This cohort of famers participated in more mechanized than non-mechanized work tasks. There were a consistent, generally dose-response relationships observed between the degree of mechanized farm work and risk of overweight or obesity.

US data suggest that the farming, forestry, and fishing industries are amongst the more physically demanding occupational sectors (Choi et al., 2010). Such occupational demands are associated with lower risks for obesity (Choi et al., 2010). So in some ways, our study findings are counterintuitive, as like others (Bonauto et al., 2014) we identified that risks for obesity are high among farm people. This suggests that other factors involved in energy balance explain

the increased risk for obesity among farm people. While not limited to farm people per se, there is evidence that rural populations have lower leisure-time physical activity levels (Martin et al., 2005) and poorer dietary behaviors (Dean and Sharkey, 2011) than urban populations. Differences may reflect less favorable socioeconomic conditions and built environments. The price of fruits and vegetables is a barrier for lower-income families (Cassady et al., 2007) and there are fewer supermarkets in rural areas (Dean and Sharkey, 2011) which together can make it challenging for people in rural areas to eat healthily, including those on farms that do not have diverse production practices.

Many work practices in our Saskatchewan sample were highly mechanized. We are unaware of any analogous studies conducted with farm families. We clearly show that increasing involvement in mechanized tasks, which have lower energy expenditures than non-mechanizes tasks, is related to overweight and obesity. This indicates that mechanization on farms is potentially important in the etiology of overweight and obesity. It also suggests that past studies that are based upon heterogenous industrial sectors may provide findings that are misleading when compared to studies of more specific occupations.

Limitations of our study should be recognized. Results were based on cross-sectional data which limits our ability to consider temporality. A second limitation surrounds our reliance on self- and proxy-reports for all study variables. This undoubtedly led to some misclassification of our study variables. Such misclassification is likely non-differential and would attenuate any observed associations towards no effect.

Strengths of our study also warrant comment. Analyses were based on a well-established cohort of farmers from an inclusive sampling frame. Our sampling was developed taking into account the full geographic, and resultant farming practice, range of agriculture in Saskatchewan. We were able to consider ranges of exposure to different types of farm work allowing the assessment of dose-response. We were also able to compare findings from the

cohort with those from the Canadian and Saskatchewan population using comparable measures.

Our findings suggest that there is an increased risk of being overweight or obese with higher levels of mechanization. This is of obvious public health importance as the negative health consequences of obesity are well established (Must et al., 1999). Obesity also has consequences in terms of lost productivity, and on farms this has been demonstrated in terms of sick leave for back disorders stemming from tractor work as well as leaves from work due to disability related to obesity (Hartman et al., 2006). All of these consequences can negatively impact the health of farmers and the viability of farm operations.

Despite these negative impacts, we are not promoting a reduction in farm mechanization as a viable intervention. First, replacement of mechanized with non-mechanized tasks will undoubtedly lead to more opportunity for exposure to risk and hence injury. Second, reducing mechanization would reduce productivity in an already economically unstable occupational environment. Therefore, addressing heightened risks for obesity amongst farm people will need to be done within the context of an occupational environment that is becoming increasingly mechanized. Researchers and employers are developing strategies to incorporate light intensity activity into sedentary office occupations (e.g., standing desk, movement breaks) (Chau et al., 2010), and similar approaches could be considered for sedentary farming tasks. Increased efforts should be placed on increasing leisure-time physical activity amongst farm people, particularly those who spend most of their occupational time being sedentary. Finally, interventions could focus on the other behavioral determinants of obesity such as improving eating and sleep behaviors.

Conclusion

This novel Canadian analysis examined engagement in different types of mechanized and non-mechanized work and how these related to overweight and obesity. Obesity is a major health

issue on farms, and as such requires attention at both clinical and population health levels of intervention. While the mechanization of farm work has obvious benefits in terms of productivity, its potential effects on risks for overweight and obesity must be recognized.

Conflict of Interest Statement

No conflicts of interest to declare by any author.

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Statistics Canada., 2012. Table 105-0503 - Health indicator profile, age-standardized rate, annual estimates, by sex, Canada, provinces and territories. CANSIM, Canadian Community Health Survey (CCHS), Annual Component.

Table 1: Prevalence of overweight and obesity overall and by gender/age in individuals involved in the Saskatchewan Farm Injury Cohort, Phase 2, 2013

Characteristic	BMI					
	Non-overweight (<25.0)		Overweight (25.0-29.9)		Obese (≥30.0)	
	n	(row%)	n	(row%)	N	(row%)
Farm Cohort overall	914	(34.9)	1036	(39.6)	669	(25.5)
Farm Cohort by age and sex						
Males, Age (years)						
7-19	67	(52.3)	35	(27.3)	26	(20.3)
20-44	119	(34.9)	136	(39.9)	86	(25.2)
45-64	130	(17.4)	378	(50.5)	241	(32.2)
65+	93	(25.3)	173	(47.1)	101	(27.5)
Female, Age (years)						
7-19	77	(79.4)	14	(14.4)	6	(6.2)
20-44	105	(57.4)	52	(28.4)	26	(14.2)
45-64	246	(43.8)	183	(32.6)	133	(23.7)
65+	77	(40.1)	65	(33.9)	50	(26.0)
Overall populations, age and sex standardized (adults only)						
Farm Cohort (n=2394)[1]	*770*	(40.8)	*987*	(36.7)	*637*	(22.5)
Canada[1,2]		(49.3)		(33.1)		(17.6)
Saskatchewan [1,2]		(42.2)		(33.1)		(24.7)

Note: (1) Overall prevalence estimates for Farm Cohort, Canada, and Saskatchewan are adjusted using the 1991 Canadian Census population structure;[24] (2) Age-adjusted prevalence estimates for Saskatchewan and Canada are taken directly from the Canadian Community Health Survey, 2012 (for adults 18 and over)[25]

Table 2. Reported exposures to specific farm work tasks by metabolic equivalent scoring

Type of work	Number of Days/year					Energy Expenditure Rate for Activity (METs)
	5%	25%	50% (Median)	75%	95%	
Mechanized						
Operate ATV's	0	0	10	60	240	4.0
Operate power tools	0	2	10	30	200	4.0
Tractor maintenance	0	1	3	6	19	3.0
Combine maintenance	0	1	3	5	13	3.0
Operate tractors	1	15	38	63	150	2.8
Operate combines	0	1	13	25	44	2.8
Non-mechanized						
Lift heavy objects	0	0	10	50	300	8.0
Shovel or pitchfork	0	0	10	20	120	7.8
Routine chores with large animals	0	0	0	200	365	4.5
Veterinary activities	0	0	0	20	90	4.5
Routine chores with small animals	0	0	0	0	350	4.5
Herd maintenance activities	0	0	0	6	40	4.0
Work with hands over shoulder height	0	0	2	10	100	3.0

MET = Metabolic Equivalent of Task; 1 MET = 3.5 kcal/kg body weight/hour

For operation of tractors, tractor maintenance, operation of combines, and combine maintenance, reported hours per year were translated to days per year at a rate of 8 hours per day

Table 3: Adjusted relative risk of overweight and obesity by farm work and specific farm work tasks

	BMI				Relative Risk*			
	Overweight		Obese		Overweight vs. Non-overweight		Obese vs. Non-overweight	
	n	row%	n	row%	RR	95% CI	RR	95% CI
Total hours of farm work (mechanized and non-mechanized)								
None	65	(32.3)	47	(23.4)	1.00	-	1.00	-
Part-time (1 to 30hrs/week)	326	(33.2)	224	(22.8)	0.97	(0.83-1.14)	1.04	(0.82-1.32)
Full-time (>30hrs/week)	598	(45.0)	378	(28.4)	1.12	(0.96-1.30)	1.20	(0.95-1.52)
Common mechanized types of farm work								
Operate tractors, days/yr								
None	200	(29.9)	140	(21.0)	1.00	-	1.00	-
1-12	205	(36.8)	123	(22.1)	1.07	(0.94-1.22)	1.01	(0.83-1.23)
13-38	253	(46.5)	146	(26.8)	1.21	(1.06-1.39)	1.18	(0.97-1.44)
>38	316	(45.5)	220	(31.7)	1.20	(1.05-1.37)	1.27	(1.05-1.53)
Operate combines, days/yr								
None	375	(33.3)	258	(22.9)	1.00	-	1.00	-
1-8	188	(41.9)	100	(22.3)	1.07	(0.95-1.20)	0.98	(0.81-1.18)
9-19	152	(44.6)	93	(27.3)	1.17	(1.03-1.32)	1.20	(1.01-1.43)
>19	247	(47.8)	166	(32.1)	1.27	(1.14-1.43)	1.34	(1.13-1.58)
Operate ATV's, days/yr								
None	396	(38.8)	252	(24.7)	1.00	-	1.00	-
1-14	158	(32.5)	134	(27.6)	0.94	(0.83-1.07)	1.09	(0.93-1.28)
15-60	234	(43.9)	117	(22.0)	1.07	(0.96-1.19)	0.99	(0.83-1.19)
>60	187	(42.6)	132	(30.1)	1.07	(0.95-1.21)	1.18	(1.00-1.40)
Common non-mechanized types of farm work								
Lift heavy objects, days/yr								
None	408	(34.6)	296	(25.1)	1.00	-	1.00	-
1-10	213	(42.3)	129	(25.6)	1.12	(1.01-1.25)	1.10	(0.94-1.29)
11-50	181	(46.2)	100	(25.5)	1.14	(1.02-1.28)	1.07	(0.90-1.28)
>50	160	(43.2)	101	(27.3)	1.02	(0.90-1.15)	0.98	(0.82-1.16)
Shovel or pitchfork, days/yr								
None	391	(34.8)	294	(26.1)	1.00	-	1.00	-
1-10	292	(41.9)	163	(23.4)	1.01	(0.91-1.12)	0.89	(0.77-1.04)
11-20	109	(48.0)	56	(24.7)	1.18	(1.05-1.33)	1.08	(0.88-1.32)
>20	175	(42.4)	113	(27.4)	1.03	(0.91-1.16)	0.98	(0.83-1.15)
Do routine chores with large animals, days/yr								
None	551	(38.5)	367	(25.6)	1.00	-	1.00	-
1-60	122	(36.6)	64	(19.2)	1.00	(0.87-1.15)	0.82	(0.65-1.04)
61-200	138	(42.0)	104	(31.6)	1.04	(0.92-1.18)	1.08	(0.92-1.28)
>200	139	(42.1)	83	(25.2)	0.93	(0.81-1.05)	0.86	(0.71-1.04)

Note: *Relative risk adjusted for age, sex, socioeconomic status and clustering

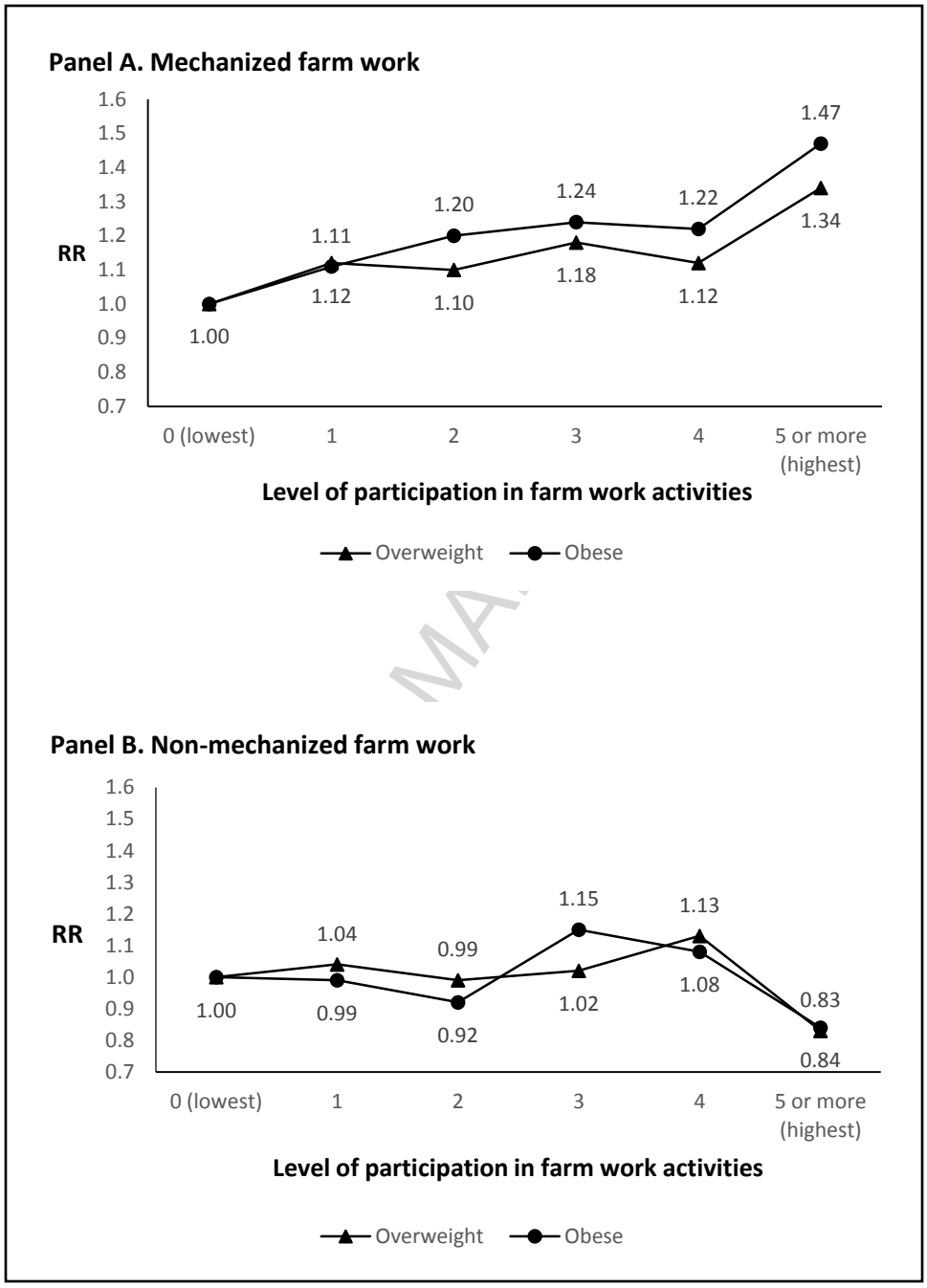

Figure 1. Relative risk of obesity and overweight associated with degree of involvement in mechanized (Panel A) then non-mechanized (Panel B) farm work tasks, Saskatchewan Farm Injury Cohort, Phase 2 (2013), adjusted for age, sex, socioeconomic status, and clustering of individuals within farms

Highlights

- We study the prevalence of overweight and obesity in a large farm cohort
- We relate the degree of mechanized and also non-mechanized farm work to the occurrence of being overweight or obese
- Mechanized work on farms is associated with higher levels of obesity