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Prevalence of work-related musculoskeletal symptoms among US large-herd dairy parlor workers

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Abstract

Background—Dairy production in the US is moving towards large-herd milking operations resulting in an increase in task specialization and work demands.

Methods—A modified version of the Standardized Nordic Questionnaire was administered to assess MSS prevalence among 452 US large-herd parlor workers. Worker demographics and MSS prevalences were assessed, and differences based on parlor configuration (i.e., herringbone, parallel, rotary) were computed.

Results—Three-fourths (76.4%) of parlor workers reported work-related MSS in at least one body part. Highest prevalences were reported in the upper extremity (55%). Herringbone workers reported a higher prevalence of MSS in the wrist/hand, and rotary workers reported higher prevalences of MSS in the neck, upper back, and shoulders.

Conclusions—Our findings draw attention to higher work-related MSS in the upper extremity among dairy parlor workers. As the trend toward larger herd sizes on US dairy farms continues, the need for further health and safety research will increase.

Keywords

agriculture; dairy; ergonomics; injury; musculoskeletal

INTRODUCTION

Dairy production in the US has steadily moved toward large-herd (>500 head) milking operations due to associated economies of scale [Reinemann,]. In 2009 there were 65,000 dairy operations in the US, down 33% since 2001, and down 90% since 1970. During the same period, milk production and herd sizes increased. In 2009, large-herd operations

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produced 56% of US milk, up from 35% in 2001, and operations with 2,000 heads or more accounted for 30% of milk production, up from 12% in 2001 [NASS, 2010]. For dairies with larger herd sizes production costs favor milking in parlors (i.e., loose- or free-stall housing where cows are directed into a dedicated facility for milking) versus stanchion milking (i.e., conventional housings where cows are milked while tethered in stalls) [Katsumata and Tauer, 2008]. In 2006, 78% of US dairy cows were milked in a parlor compared to 54.9% in 1996, and 100% of large-herd farms used a milking parlor [USDA, 2007]. Large-herd dairy parlors often operate 24-hr a day and 7 days a week while milking cows two to three times per day. The majority of milkers in large-herd US dairies constitute a vulnerable working population as previous research has shown a high proportion (84.7%) being of Mexican descent [Roman-Muniz et al., 2006]. The industry trend toward a large-herd, mass-production production model has led to increased task specialization and work demands and potentially increased risk of work-related musculoskeletal symptoms (MSS) among parlor workers.

Prior studies have examined work-related injuries and MSS among dairy farmers on smaller-herd size operations [Stål and Pinzke, 1991; Pratt et al., 1992; Gustafsson et al., 1994; Lower et al., 1996; Holmberg et al., 2002; Pinzke, 2003; Kolstrup et al., 2006; Nonnenmann et al., 2008; Lunner Kolstrup, 2012], which included both farmers and workers who performed numerous job tasks around the farm. No prior study, however, has investigated work-related MSS among US large-herd parlor workers. US large-herd dairies are unique in that workers are assigned to specific farm operations such as milking, cow or calf-care, feeding, or maintenance. Milkers perform highly specialized and repetitive tasks throughout the work shift. Parlor milking requires the repeated lifting and attachment of a milking unit, weighing up to 3.5 kg [Stål et al., 2000], to a cow's udder while working in close proximity to a cow's hind legs thus increasing the risk of being kicked when performing milking tasks. Large-herd parlor milking involves exposure to physical risk factors such as awkward postures, repetitive motions, high muscle loads, minimal opportunity for rest and harsh environmental conditions which may increase the risk for development of work-related MSS [Douphrate et al., 2012].

Milking parlor configurations are characterized by the orientation of the cows in relation to each other and in relation to the milker. The orientation of the cows to the milker dictates udder accessibility and may have an influence on the physical demands placed on the milker. There are three types of parlor configurations: herringbone, parallel, and rotary (Fig. 1). In herringbone parlors, cows are oriented 40–45° away from the milking pit where milkers work. A unique work feature of the herringbone configuration involves a worker having to reach around a hind leg of a cow to access the udder. In parallel parlors, cows are oriented parallel to one another and perpendicular to the milkers who access the udder by reaching between a cow's hind legs. In rotary parlors, cows are moved on a revolving circular platform. Milking tasks are performed as each cow passes by each worker who works in a location around the milking carousel. Milkers access the udder the same as in a parallel configuration but with the additional dynamic of the cow moving past the stationary worker. In 2006, 47% of US large herd parlors were herringbone, 32% parallel, and 5% rotary [USDA, 2007].

No prior studies have investigated prevalent MSS among US large-herd dairy parlor workers. Furthermore, exposures that place workers at risk for work-related MSS may be differentially distributed across parlor configuration. Therefore, this study's primary aim was to estimate the prevalence of work-related MSS among large-herd parlor workers in Western US states. A secondary aim was to assess differences in prevalence of MSS based on parlor configuration.

METHODS

Study Design, Sample and Procedures

Parlor workers (i.e., milkers) were recruited from 32 large-herd dairy farms in five Western US states (Table I). Average herd size of sampled dairy farms was 2,673 (SD 1,338). Dairy owners provided their signed consent after being informed about the study purpose and procedures. All parlor workers aged 18 years or older were invited to participate. A total of 452 (99.6% of eligible parlor workers), an average of 14 workers per dairy, agreed to participate upon providing written consent; they received $20 in appreciation for their time. The University of Texas Health Science Center at Houston Committee for the Protection of Human Subjects approved the study.

Worker demographic (i.e., age, gender) and anthropometric characteristics (i.e., weight, height, functional grip reach, dominant hand) were collected. Functional grip reach was defined as the horizontal distance between the vertical plane of the back and the center of a 1.25 inch (3.2 cm) diameter dowel gripped in the right hand of a subject standing erect with the back against a wall and the arm and hand extended forward horizontally with the shoulder at 90° flexion [Gordon et al., 1989]. Health-related (i.e., smoking and body mass index), work-related features (i.e., time working in the parlor, having other non-dairy job), usual work shift, difficulty with performance specific milking tasks, and MSS data were collected with a questionnaire administered by a bilingual (English/Spanish) researcher who is a dairy veterinarian. This was to ensure that respondents understood questions, thus preventing reading literacy from affecting survey responses. Each questionnaire took about 30 min to complete. In each parlor we sampled two shifts of workers, the morning shift after they finished their work shift, and the evening shift before they began their work shift. Managers and owners were not present during questionnaire administration. We measured a few parlor structural characteristics such as, floor to pit height, floor to udder height and distance from pit edge to center of cow udder (e.g., worker reach).

Musculoskeletal Symptoms (MSS)

Twelve-month period prevalence of work-related MSS was assessed with a modified version of the Standardized Nordic Questionnaire [Kuorinka et al., 1987], a widely used tool [Gustafsson et al., 1994; Anton et al., 2002; Merlino et al., 2003; Pinzke, 2003; Rosecrance et al., 2006; Nonnenmann et al., 2008] with good test-retest reliability [Rosecrance et al., 2002] and validity [Descatha et al., 2007]. For nine anatomic sites (neck, shoulder, upper back, lower back, elbow, wrist/hand, hip/thigh, knee, feet), the questionnaire asks if, during the last 12-months, the respondent (1) had a work-related ache, pain, discomfort, which (2) had prevented the respondent from doing the day's work, and (3) if the respondent had seen an MD, an osteopath or a chiropractor about the reported symptom. During the administration of the questionnaire, a Spanish-speaking researcher explained to each worker that a work-related MSS could be any ache, pain or discomfort that was experienced in any body part during or after a milking workshift. This is accordance with the original design and testing of the survey instrument [Kuorinka et al., 1987]. For each of these anatomical sites, we created a dichotomous variable indicating whether a worker had experienced MSS or not; and we created a summary variable indicating whether participants had experienced MSS in any body part. Additionally, to maximize statistical power, we examined MSS by sites grouped into three anatomical regions (i.e., neck and upper back; upper extremity: shoulder, elbow and wrist/hand; and lower extremity: hip/thigh, knee and feet). Due to small numbers, questions related to having been prevented from doing work and having seen a physician were analyzed based on the summary variable of having MSS in any body part.

Statistical Analysis

The overall approach to analysis was to generate descriptive statistics on the total sample and then test for differences by parlor style. *F*-test *P*-values for differences in herd size and participants by parlor type were obtained from linear regression models. Wald test *P*-values for differences in MSS by parlor type were obtained from logistic regression models (i.e., dichotomous MSS variables as the outcome). Regression models were clustered by parlor to account for participants within the same parlor sharing some characteristics. We controlled for age, gender and BMI in all models. We did not test for differences by state nor did we cluster our analysis by state since there are no differences in the way dairy parlors operate in the states we selected. Statistical significance was declared at the 0.05 level. Statistical analysis was performed with Stata/MP® 12.1.

RESULTS

Parlor dimensions varied based on configuration. As shown in Table I, mean pit height was 104.8 cm (SD 4.9), 114.0 cm (SD 7.1), and 102.5 cm (SD 6.7) for herringbone, parallel, and rotary parlors, respectively; and mean distance from pit edge to forward teats was 45.1 cm (SD 7.4), 46.3 cm (SD 3.1), and 49.0 cm (SD 5.5) for herringbone, parallel, and rotary parlors, respectively. Mean vertical distance from floor to udder was 155.3 cm (SD 7.4), 163.3 cm (SD 7.4), and 151.9 (SD 8.2) for herringbone, parallel, and rotary parlors, respectively.

Mean age of participants was 30.3 years (SD 9.0), and 89.4% of participants were male (Table II). Ninety-seven percent of sampled workers were Hispanic and right-hand dominant. Mean height was 167.8 cm (SD 11.9) and 156.8 cm (SD 7.0) for males and females, respectively; and functional grip reach was 68.1 cm (SD 6.9) and 63.7 cm (SD 2.9) for males and females, respectively (data not shown). The percentage of participants with an overweight or obese body mass index (BMI) was 55.6%, and 33.2% of participants were former or current smokers. Regarding job characteristics, participants worked 9.1 hr per day (SD 1.8), 5.9 days per week (SD 0.6), and 49.7 weeks per year (SD 7.9) and had worked 4.2 years (SD 4.3) in a dairy parlor, with 98% reporting not having another job. Overall, working any shift was usual for 41.8% of the participants with notable ($P = 0.003$)

differences by configuration (only 13% in herringbone, 31.7 in rotary, and 57.7% in parallel).

Participants reported the most difficult milking tasks as being teat stripping (37.6%), followed by cluster attachment/detachment (31.9%). The most difficult task (40%) for herringbone workers was cluster attachment/detachment and teat stripping in rotary (41%). Approximately, 85% of participants had been kicked or stepped on by a cow while milking. Over a quarter of workers, overall and among parallel and rotatory workers specifically (herringbone 17%), were kicked or stepped on in more than one body part. The single body part most frequently kicked or stepped on was the wrist/hand (30.1%). A higher percentage of herringbone workers (42.0%) reported having been kicked in the upper extremity as compared to parallel (35.5%) and rotary workers (29.8%).

Table III displays the 12-month period prevalence of MSS among parlor workers. Over three-fourths (76.4%) of parlor workers reported experiencing work-related MSS in any anatomical site in the prior 12-month period; 56.4% reported MSS in two or more sites (data not shown). Less than 8% of workers were prevented from working (7.5%) or seeing a physician (7.8%) in the previous year due to any work-related pain in any body part.

By body region, the highest prevalences of MSS was reported in the upper extremity region (55.2%) followed by lower extremity (51.8%), neck and upper back (46.5%), and lower back (30.1%). By specific body site, the highest prevalences of work-related pain were reported in the feet (47.2%), upper back (42.0%), and shoulders (40.1%) while the lowest were in the elbows (18.6%) and hips and thighs (19.2%).

Although we did not find statistically significant ($P < 0.05$) differences in MSS prevalence by parlor configuration, rotary workers had a noticeable higher prevalence than herringbone workers of work-related pain in neck (33.3% vs. 17.0%), upper back (47.4% vs. 33.0%), hips and thighs (27.0% vs. 12.0%), and knees (28.4% vs. 17.0%). Prevalences in parallel workers were between the other configurations except for elbow pain, which was slightly higher in parallel workers.

Additional analysis of work-related MSS by worker and sample characteristics revealed limited significant findings. Despite limited representation in our sample, females generally had higher prevalence of work-related MSS than males (not statistically significant); and as expected, those who reported having been stepped on or kicked in specific body parts also reported having MSS in those same body parts. This data will be made available by the corresponding author upon request.

DISCUSSION

To our knowledge, the present study is the first to estimate the prevalence of MSS among Western US large-herd parlor workers. Musculoskeletal symptoms are very common among parlor workers since 76% reported one or more symptoms the past year. Symptoms primarily involved the upper extremity, specifically shoulders and wrist/hand. Over three quarters of parlor workers reported work-related MSS in at least one body part, and over half reported work-related MSS in two or more body parts. Interestingly, almost half of the parlor workers reported work-related MSS in the feet. No statistically significant associations were found between work-related MSS in specific anatomical sites and parlor configurations. However, MSS prevalences in specific body parts were notably higher in certain parlor configurations.

Overall, our study adds to the literature on work-related musculoskeletal problems among dairy workers. Dairy farming is a very physically demanding occupation and has the second highest prevalence of injuries among all US agriculture groups [NIOSH, 1993; Boyle et al., 1997; Crawford et al., 1998]. The majority of these injuries originate from interactions with dairy cattle during milking activities [Pratt et al., 1992; Waller, 1992; Boyle et al., 1997], stressing the need for studies such as ours specifically addressing milking parlor workers.

Our results regarding the high prevalence of work-related MSS in upper extremity among parlor workers are consistent with previous findings. Douphrate et al. [2012] reported US large-herd parlor workers may be subject to exposures (awkward posture, high repetition, and inadequate rest) associated with the development of shoulder pathology. Using surface electromyography (EMG) and electrogoniometry, Pinzke et al. [2001] reported high muscle loads in combination with extreme positions and movements of the hand and forearm might contribute to the development of injuries among milkers.

Our findings are also consistent with the very limited literature on dairy farmers and workers in the US (i.e., Iowa) [Nonnenmann et al., 2008], and other countries (Sweden, Australia, and Ireland) [Stål and Pinzke, 1991; Gustafsson et al., 1994; Lower et al., 1996; Pinzke, 2003; Kolstrup et al., 2006; Osborne et al., 2010; Lunner Kolstrup, 2012] reporting higher prevalences of MSS in the upper extremity and feet, and lower prevalences of pain in the lower back. However, no directly comparable data on the prevalence of MSS among parlor workers exist. We focused on milking parlor workers on large-herd farms in the US. There are prior studies on work-related MSS among dairy farmers and workers on smaller-herd operations mostly outside of the US. Differences in task specializations, herd sizes (that is, work volumes) and culture may influence self-reported symptoms among workers. Dairy owners and hired workers on smaller herd operations (<500 head) often perform many tasks around the farm due to lack of hired labor while large-herd operations hire workers who specialize in tasks such as milking, feeding, cow/calf care, maternity, and mechanical maintenance. The absence of similar studies involving large-herd parlor workers in other countries makes it difficult to compare our findings to findings from other studies.

Regarding the high prevalence of work-related MSS in the feet, the most likely explanation is a combination of long standing durations, hard walking surfaces and poor footwear. Parlor workers work 8–12-hr shifts with few, if any, rest breaks or opportunities to sit. Parlors are constructed with concrete flooring, and some parlors install non-slip rubber matting to prevent pooling of water. However, rubber floorings are often not replaced after they lose their anti-fatigue properties. Footwear worn by parlor workers are often water-resistant rubber boots which may be heavy with minimal shock-absorption or ankle support properties. Intervention strategies related to these factors should be implemented to reduce the high prevalences of pain, as well as the increased fatigue and potential reduction in productivity.

Our secondary aim was to examine differences in work-related MSS by parlor configuration. Although differences were not statistically significant, herringbone workers had a higher prevalence of MSS in the wrist/hand, and rotary workers had higher prevalences of MSS in the neck, upper back and shoulders. These differences may reflect different physical demands associated with each parlor configuration. Herringbone workers often access the udder to attach a milking unit by reaching around a hind leg of a cow, a maneuver involving awkward postures of the upper extremity. Additionally, a cow's positioning in a herringbone parlor enables her to more effectively see behind her as compared to cows in parallel and rotary parlors. A cow's position in a herringbone parlor combined with her natural "round-house" method of kicking forward and to the side increases the risk of a worker being kicked which our findings suggest. Rotatory and parallel workers have a longer reach than herringbone workers since the udder is farther from the pit platform edge. Rotary workers are challenged with the additional dynamic of the cow moving on a rotating carousel. The higher prevalence of MSS in lower extremity among rotatory workers may be the result of having to stand in one location for longer durations as cows are moved to the worker. Conversely, herringbone and parallel workers must walk to each cow to perform milking tasks. Finally, some of the differences in MSS may be related to shift work. We found statistical significant differences on the shift worked by the participant by configuration type. These differences are most likely the unexpected result of our sampling strategy given that worker staffing practices are usually the same among dairy farms, regardless of parlor configuration. However, there is evidence that some work shifts (e.g., night shifts) are associated with higher injury rates [Salminen, 2010; Wong et al., 2011], but not specifically with MSS. Therefore, our study did not produce strong evidence to assume that work shift differences by parlor configuration impacted our findings. Further research should confirm our findings.

As previously mentioned, female parlor workers had a higher prevalence of work-related MSS than their male counterparts. Additionally, our findings indicate parlor workers are overweight or obese, which are risk factors for musculoskeletal disorders [Bernard, 1997; Pollack et al., 2007]. Therefore, we cannot rule out the potential contribution of obesity to the development of MSS or musculoskeletal disorders in this working population, despite finding no statistically significant differences by BMI categories.

We also collected anthropometric measures among parlor workers with the intent to determine if parlor design was appropriate for the body dimensions of this worker population. Anthropometric data for international workers is limited; therefore we compared our worker anthropometric data to other worker populations. Our findings suggest Hispanic parlor workers are shorter in stature and have a smaller functional grip reach than US military personnel [Gordon et al., 1989]. Hispanic US parlor workers are similar in stature and have a comparable functional arm reach as northwest Mexico automotive workers [Luccero-Duarte et al., 2012], Guadalajara industrial workers, US-Mexican maquila workers, Ciudad de Leon industrial shoe workers, Medellin (Colombia) workers [Ávila et al., 2007], and Baja California maquila workers [Veloz et al., 2004]. Our findings suggest rotary parlors necessitate a longer reach to access the udder, as compared to herringbone and parallel parlors. Mean horizontal and vertical distances to udder suggest Hispanic workers may be approaching or exceeding their functional reach envelope limit when repeatedly accessing the udder to perform milking tasks [Konz and Johnson, 2004]. These parlor dimensions may contribute to worker fatigue and the development of musculoskeletal injury. Further research should address parlor design fitted for a predominantly Hispanic workforce.

Several methodological issues must be considered when interpreting our findings. First, the cross-sectional nature of the survey limits our capability to establish causality. Second, period prevalence rates were based on self-reported MSS, which may result in an over or under estimation error. However, it is unlikely that the error in our measurement of MSS was differential based on parlor configuration. Furthermore, researchers often rely on standardized, validated and widely used self-report mechanisms such as the Nordic questionnaire for the assessment of MSS.

Third, although for several anatomical sites the differences in MSS by parlor configuration were substantial, our study lacked statistical power. Sample size, and therefore statistical power, in cluster designs is driven by the number of clusters (i.e., parlors), the number of observations (i.e., parlor workers) for clusters sampled and the intraclass correlation coefficient (ICC) between observations within clusters, which is typically very small (0.002–0.005). However, estimates of the ICC on our data (not shown) were found to be much greater. Thus, the similarity of MSS reports between parlor workers within the same parlor working the same work shift was very high. Post-hoc power analyses taking into account these levels of ICC suggest we will need to increase the number of workers within parlor by five times or to double the number of parlors in the study. The feasibility of any of these two options is low given the challenges in enrolling farms and their workers. Alternatively, steps could be taken trying to reduce the effect of the shared environment. One approach would be to interview a moderately higher number of workers in each work shift.

Fourth, almost all the participants in our study were Hispanic (97.1%) and male (89.4%). Hispanic labor on US dairies is common (e.g., 50% in New York [Maloney, 2002], 85–89% in Colorado [Roman-Muniz et al., 2006; Reynolds et al., 2009], 92% in Vermont [Baker and Chappelle, 2012], and 94% in California [Eastman et al., 2012]). We did not ask for immigration status but evidence suggests that Hispanic immigrant men in the US, particularly those with lower education levels, illiteracy, and limited English proficiency, tend to occupy lower-wage, higher-hazard jobs sustain higher rates of work-related injuries and illnesses than US-born Hispanic and other non-Hispanic male groups [Dávila et al., 2011]. Thus, our results may reflect the overall higher prevalence of health conditions among Hispanics in the US. Moreover, safety issues related to low literacy levels of these workers on dairy farms are of concern to dairy owners. For instance, in a survey of safety behaviors among US dairy producers known to employ Latino workers in the Midwest US, two-thirds of respondents rated 5 of 10 safety behaviors as of concern due to their employees' inability to read, write, speak, or understand English [Opatik and Novak, 2010]. Although possible, we consider unlikely survey responses were affected by low literacy levels since data collection was administered by an interviewer, and in Spanish when needed.

In summary, MSS are very common among US large-herd parlor workers. Symptoms primarily involve the upper extremity, specifically shoulders and wrist/hand. As the trend toward larger herd sizes continues, the need for effective health and safety intervention research in the US dairy industry will increase. Future US parlor research should address administrative and engineering solutions aimed at reducing exposure to risk factors for work-related MSS among parlor workers, while simultaneously improving worker efficiency, productivity, and ease of work. Researchers should engage and partner with dairy owners and workers to generate cost-effective injury prevention strategies.

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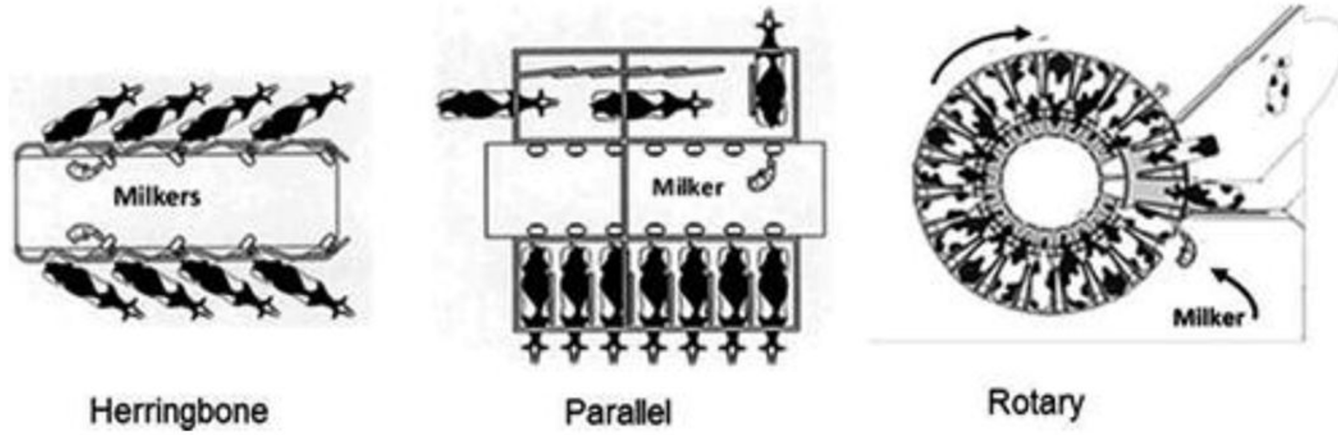

Figure 1.
Milking parlor configurations.

Table I.

Characteristics of Dairy Parlors

	Total	Parlor type			
		Herringbone	Parallel	Rotatory	
Characteristic	**% (n) or Mean (SD)**	**% (n) or Mean (SD)**	**% (n) or Mean (SD)**	**% (n) or Mean (SD)**	**p-value**[a]
State					NA
Colorado	31.3 (10)	50.0 (4)	35.3 (6)	0	
New Mexico	15.6 (5)	37.5 (3)	11.8 (2)	0	
South Dakota	9.4 (3)	0	0	42.9 (3)	
Texas	34.4 (11)	0	47.1 (8)	42.9 (3)	
Utah	9.4 (3)	12.5 (1)	5.9 (1)	14.3 (1)	
Herd size					0.352
Mean (SD)	2,673 (1,338)	2,088 (1,329)	2,884 (1,224)	2,823 (1,608)	
Min – Max	680 – 6,000	791 – 5,000	680 – 6,000	800 – 5,000	
Pit height (in cm)					<0.001
Mean (SD)	109.2 (8.2)	104.8 (4.9)	114.0 (7.1)	102.5 (6.7)	
Min – Max	94.0 –121.9	96.7 – 111.8	94.0 – 121.9	94.0 – 114.3	
Floor to udder height (in cm)					0.004
Mean (SD)	158.8 (8.9)	155.3 (7.4)	163.3 (7.4)	151.9 (8.2)	
Min – Max	142.2 –176.5	144.8 – 165.1	147.3 – 176.5	142.2 –166.4	
Pit edge to center of cow udder (in cm)					0.401
Mean (SD)	46.6 (5.0)	45.1 (7.4)	46.3 (3.1)	49.0 (5.5)	
Min – Max	38.1 – 58.4	38.1 – 58.4	40.6 – 53.3	38.1 – 54.6	
Participants					0.535
Mean (SD)	14.2 (4.9)	12.5 (5.0)	14.7 (4.3)	15.1 (6.5)	
Min – Max	5 – 25	7 – 23	8 – 24	5 – 25	
Total	100.0 (32)	25.0 (8)	53.1 (17)	21.9 (7)	

[a]F-test from linear regression models clustered by parlor (see statistical section for details).

Table II.

Sample characteristics by parlor type.

		Parlor type			
	Total	Herringbone	Parallel	Rotatory	
Characteristic	% (n) or Mean (SD)	% (n) or Mean (SD)	% (n) or Mean (SD)	% (n) or Mean (SD)	p-value[a]
Age (in years) [Mean(SD)]	30.3 (9.0)	29.7 (9.1)	30.2 (8.5)	31.2 (10.1)	0.667
Gender					0.781
Female	10.6 (48)	8.0 (8)	12.1 (30)	9.6 (10)	
Male	89.4 (404)	92.0 (92)	87.9 (218)	90.4 (94)	
Hispanic					0.108
No	2.9 (13)	7.0 (7)	2.0 (5)	1.0 (1)	
Yes	97.1 (439)	93.0 (93)	98.0 (243)	99.0 (103)	
Height (in cm) [Mean(SD)]	166.8 (30.3)	167.4 (29.7)	166.5 (30.2)	166.7 (31.2)	0.959
Weight (in kg) [Mean(SD)]	73.4 (13.4)	73.6 (12.9)	72.4 (13.1)	75.4 (14.3)	0.413
Grip reach (in cm) [Mean(SD)]	67.6 (6.72)	67.5 (4.9)	67.2 (4.3)	68.7 (11.3)	0.460
Dominant hand					0.701
Right	96.7 (437)	96.0 (96)	97.6 (242)	95.2 (99)	
Left	3.3 (15)	4.0 (4)	2.4 (6)	4.8 (5)	
Smoking					0.668
Never	66.8 (302)	67.0 (67)	65.3 (162)	70.2 (73)	
Ex-smoker	17.7 (80)	21.0 (21)	17.3 (43)	15.4 (16)	
Current	15.5 (70)	12.0 (12)	17.3 (43)	14.4 (15)	
Body Mass Index					0.969
Underweight	2.5 (11)	3.0 (3)	2.4 (6)	2.0 (2)	
Normal	42.0 (189)	42.0 (42)	44.0 (109)	37.3 (38)	
Overweight & obese	55.6 (250)	55.0 (55)	53.6 (133)	60.8 (62)	
Time working in dairy parlor					
Hours per day [Mean(SD)]	9.1 (1.8)	9.4 (1.8)	8.7 (1.6)	9.9 (1.7)	0.124
Days per week [Mean(SD)]	5.9 (0.6)	5.8 (0.6)	5.9 (0.5)	5.7 (0.8)	0.382
Weeks per year [Mean(SD)]	49.7 (7.9)	50.1 (7.2)	48.9 (9.6)	51.5 (0.6)	0.003
Years [Mean(SD)]	4.2 (4.3)	3.9 (4.4)	4.5 (4.7)	3.7 (3.4)	0.497
Hours per day					0.322
Up to 8	59.3 (268)	60.0 (60)	67.7 (168)	38.5 (40)	
Over 8	40.7 (184)	40.0 (40)	32.3 (80)	61.5 (64)	
Other Job					0.696
Yes	2.0 (9)	1.0 (1)	2.4 (6)	1.9 (2)	
No	98.0 (443)	99.0 (99)	97.6 (242)	98.1 (102)	
Usual work shift					0.003
Morning, afternoon/evening or night	58.2 (263)	87.0 (13)	42.3 (105)	68.3 (71)	
All	41.8 (189)	13.0 (13)	57.7 (143)	31.7 (33)	

Characteristic	Total	Parlor type: Herringbone	Parlor type: Parallel	Parlor type: Rotatory	p-value[a]
	% (n) or Mean (SD)	% (n) or Mean (SD)	% (n) or Mean (SD)	% (n) or Mean (SD)	
Most difficult milking task					0.147
None	8.6 (39)	7.0 (7)	6.5 (16)	15.4 (16)	
Stripping	37.6 (170)	39.0 (39)	35.5 (88)	41.4 (43)	
Attach/Detach	31.9 (144)	40.0 (40)	29.8 (74)	28.9 (30)	
Other	21.9 (99)	14.0 (14)	28.2 (70)	14.2 (15)	
Ever kicked/stepped on by cow					0.941
No	15.3 (69)	14.0 (14)	15.3 (38)	16.4 (17)	
Yes	84.7 (383)	86.0 (86)	84.7 (210)	83.7 (87)	
Body part kicked/stepped on by cow					0.793
None	15.3 (69)	14.0 (0)	15.3 (38)	16.4 (17)	
Wrist/Hand	30.1 (136)	30.0 (30)	31.5 (78)	26.9 (28)	
Ankle/Foot	12.4 (56)	14.0 (14)	10.9 (27)	14.4 (15)	
>1 body part	25.2 (114)	17.0 (17)	28.2 (70)	26.0 (27)	
Other	17.0 (77)	25.0 (25)	14.1 (35)	16.4 (17)	
Kicked/stepped on neck /upper back					0.272
No	96.2 (435)	96.0 (96)	98.0 (243)	92.3 (96)	
Yes	3.8 (17)	4.0 (4)	2.0 (5)	7.8 (6)	
Kicked/stepped on upper extremity					0.527
No	64.4 (291)	58.0 (58)	64.5 (160)	70.2 (73)	
Yes	35.6 (161)	42.0 (42)	35.5 (88)	29.8 (31)	
Kicked/stepped on lower extremity					0.922
No	81.4 (368)	81.0 (81)	82.3 (204)	79.8 (83)	
Yes	18.6 (84)	19.0 (19)	17.7 (44)	20.2 (21)	
Kicked/stepped on low back					0.271
No	98.5 (445)	96.0 (96)	98.8 (245)	100 (104)	
Yes	1.6 (55)	4.0 (4)	1.2 (3)	0.0 (0)	
Total	100.0 (452)	100.0 (100)	100.0 (248)	100.0 (104)	

[a]Wald test from logistic regressions clustered by parlor (see statistical section for details).

Table III.

Body Pain by Parlor Type

		Parlor type			
	Total	**Herringbone**	**Parallel**	**Rotatory**	
Body pain type	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**p-value[a]**
Job related pain in any body part					0.881
No	23.6 (106)	24.0 (24)	24.6 (61)	20.6 (21)	
Yes	76.4 (344)	76.0 (76)	75.4 (187)	79.4 (81)	
Job related pain in neck/upper back					0.164
No	53.5 (239)	62.0 (63)	52.8 (131)	45.5 (45)	
Yes	46.5 (208)	37.0 (37)	47.2 (117)	55.5 (54)	
Job related pain in neck					0.205
No	74.8 (330)	83.0 (83)	74.6 (185)	66.7 (62)	
Yes	25.2 (111)	17.0 (17)	25.4 (63)	33.3 (31)	
Job related pain in upper back					0.235
No	58.0 (258)	67.0 (67)	56.5 (140)	52.6 (51)	
Yes	42.0 (187)	33.0 (33)	43.5 (108)	47.4 (46)	
Job related pain in low back					0.883
No	69.9 (307)	72.0 (72)	68.5 (170)	71.4 (65)	
Yes	30.1 (132)	28.0 (28)	31.5 (78)	28.6 (26)	
Job related pain in upper extremity (shoulder, elbow and wrist/hand)					0.932
No	44.8 (199)	45.0 (45)	43.9 (109)	46.9 (45)	
Yes	55.2 (245)	55.0 (55)	56.0 (139)	53.1 (51)	
Job related pain in shoulders					0.784
No	59.9 (264)	63.0 (63)	60.1 (149)	55.9 (52)	
Yes	40.1 (177)	37.0 (37)	39.9 (99)	44.1 (41)	
Job related pain in elbows					0.439
No	81.4 (355)	86.0 (86)	79.6 (195)	84.1 (74)	
Yes	18.6 (81)	14.0 (14)	21.4 (53)	15.9 (14)	
Job related pain in wrist/hand					0.855
No	64.2 (282)	60.0 (60)	65.3 (162)	65.9 (60)	
Yes	35.8 (157)	40.0 (40)	34.7 (86)	34.1 (31)	
Job related pain in lower extremity (hip/thigh, knee and feet)					0.896
No	48.2 (214)	49.0 (49)	49.2 (122)	44.8 (43)	
Yes	51.8 (230)	51.0 (51)	50.8 (126)	55.2 (53)	
Job related pain in hips/thighs					0.071
No	80.8 (353)	88.0 (88)	80.6 (200)	73.0 (65)	
Yes	19.2 (84)	12.0 (12)	19.4 (48)	27.0 (24)	
Job related pain in knees					0.196
No	75.9 (331)	83.0 (83)	74.6 (185)	71.6 (63)	
Yes	24.1 (105)	17.0 (17)	25.4 (63)	28.4 (25)	

		Parlor type			
	Total	**Herringbone**	**Parallel**	**Rotatory**	
Body pain type	**% (n)**	**% (n)**	**% (n)**	**% (n)**	**p-value[a]**
Job related pain in feet					0.792
No	52.8 (234)	52.0 (52)	55.2 (137)	47.4 (45)	
Yes	47.2 (209)	48.0 (48)	44.8 (111)	42.6 (50)	
Prevented work due to pain in any body part					0.375
No	92.5 (417)	90.0 (90)	94.0 (233)	91.3 (94)	
Yes	7.5 (34)	10.0 (10)	6.0 (15)	8.7 (9)	
Seen a physician due to pain in any body part					0.216
No	92.2 (416)	89.0 (89)	92.3 (229)	95.2 (98)	
Yes	7.8 (35)	11.0 (11)	7.7 (19)	4.8 (5)	
Total	100.0 (452)	100.0 (100)	100.0 (248)	100.0 (104)	