

Industrialization of Dairy Operations: Ergonomic Implications

Douphrate D.¹, Rosecrance J.²

¹*University of Texas School of Public Health, San Antonio Campus*

8550 Datapoint Drive, Suite 200, San Antonio, Texas 78229, UNITED STATES

Tel 011-1-210-562-5500, Fax 011-1-210-562-5528, David.Douphrate@uth.tmc.edu

²*Colorado State University, Occupational and Environmental Health Section*

1681 Campus Delivery, Fort Collins, Colorado, 80524, UNITED STATES.

Tel 011-1-970-491-1405, Fax 011-1-970-491-2940, John.Rosecrance@Colostate.edu

Abstract

The industrialization of dairy production has led to increased occupational risk of musculoskeletal disorders among parlor workers. Questions arise regarding the effects of the work and the environment on the worker. The purpose of this project was to investigate musculoskeletal symptoms among large-herd dairy parlor workers, and assess ergonomic risk exposures involved with large-herd parlor milking operations. Musculoskeletal symptom surveys were administered to large-herd dairy parlor workers. In addition, full-shift direct measurements of exposures to muscle force and postures were taken involving the upper extremity and trunk. Preliminary results indicate 79% of large-herd dairy parlor workers experienced job-related pain in the previous 12-month period. Data also showed the highest percentages of reported job-related pain are in the feet, upper back, shoulders and wrist. Workers rated “continuing to work when injured or hurt” and “working in hot, cold, wet, humid conditions” as the two most problematic job-features associated with parlor milking. Full-shift electromyography results revealed mean peak loads of 57.8% of maximum voluntary contraction (MVC) of the flexor forearm musculature and 48.5% of MVC of the anterior deltoid. Full-shift exposure variation analysis results revealed 94% of myoelectric activity in both flexor forearm and anterior deltoid musculature was 1 second or less in duration, indicative of highly repetitive activities. Preliminary findings suggest large-herd parlor workers may be exposed to upper extremity risk factors (extreme posture, repetition, high muscle loads) associated with the development of musculoskeletal disorders.

Keywords: dairy, industrialization, ergonomics, parlor

Introduction

Over the past decade, the US dairy industry production profile has changed dramatically to more efficiently produce dairy products to meet higher consumer demands. From 1989 through 2009, the number of US milking operations decreased by 68%, while during the same period milk production increased by 32%. Increased US milk production in conjunction with a decreased number of milking operations has been driven by increased milking herd sizes. Small herd operations (<500 head) operations continue to diminish whereas large herd (500+ head) operations continue to rise (Douphrate, et al.,2009). In 1998, nearly 70% of milk produced in the US came from small herd operations. By 2009, over 60% of milk produced in the US came from large herd operations, and 31% came from operations of 2,000 head or more (NASS,2009). These changes have led to significant shifts in work tasks resulting in exposures to high repetition, forceful muscle exertions, a fast work pace, and a specialization of labor. The industrialization of dairy production has led to increased occupational risk of musculoskeletal disorders (MSDs) among parlor workers. Questions arise regarding the

effects of the work and the environment on the worker, as well as the acceptable comfort and safety in the different milking systems, when considering the higher cow throughput rates and the greater size of the herds being milked. Work demands are increased in large-herd dairy operations due to large numbers of cows being milked per unit time compared to a small-herd operation. Modern large-herd milking systems may increase the physical workload and thus have an effect on the development of MSDs in the neck, shoulder, wrist and hand. More focused research should investigate milking practices and parlor designs as they relate to worker safety and health. Additional research is vital given the trend towards large industrial milking operations.(Doupbrate, et al.,2009) The purpose of this multi-faceted project was to investigate musculoskeletal symptoms among large-herd dairy parlor workers, and asses ergonomic risk exposures involved with large-herd parlor milking operations.

Methods

Symptom Survey

An ongoing 4-year investigation involves the administration of symptom surveys to assess musculoskeletal symptoms among large-herd dairy parlor workers. A modified Nordic Musculoskeletal Questionnaire (NMQ) (Kuorinka, et al.,1987) was administered to parlor workers on dairies with milking herd sizes of 500 head or more. In addition to the standardized NMQ items, additional questions addressed dairy parlor work environment factors. The questionnaire was administered on-site by a bilingual dairy veterinarian through a structured interview to insure high response rates, completeness and accuracy.

Muscle Force Exposure

Surface electromyography (EMG) was used to assess force used by the forearm flexors and extensor muscles during the performance of milking tasks. Myoelectric activity was recorded unilaterally from the flexor digitorum superficialis (flexor forearm) extensor digitorum (extensor forearm), anterior deltoid (upper arm flexor), and upper trapezius (shoulder stabilizer and elevator). The EMG electrodes were positioned on the skin above the muscles according to standard placement procedures (Zipp,1982). Electrodes were bipolar, differentially preamplified with a gain of 1000, and bandpass filter the input EMG signals (bandwidth 20 Hz – 460 Hz) to minimize motion artifacts and high frequency noise. Electrodes were dry (i.e., do not require electrode gel), reusable, and produced negligible noise ($\leq 5 \mu\text{V}$). In addition, a reference electrode was positioned over the clavicle on the opposite side of the body from which the EMG electrodes are placed. Postural data was collected from each worker for an entire workshift and was then downloaded for analysis. A Spanish speaking dairy veterinarian was present during data collection for translation support.

Posture Exposure

Investigators used a self-recording inclinometer for the assessment of postural tilt (shoulder elevation and trunk inclination). The device utilized was a datalogger with 2 Mb of built-in memory called the Virtual Corset (MicroStrain, Inc; Williston, VT) which non-invasively and continuously collected postural exposures in two dimensions. The pager sized Virtual Corset was mounted to the posterior aspect of each upper arm, mid-way between the shoulder and elbow. A third was mounted to the posterior trunk at the level of the eighth thoracic spinous process. Postural data was collected from each worker for an entire workshift and was then downloaded for analysis. A Spanish speaking dairy veterinarian was present during data collection for translation support.

Results

Symptom Survey

To date, a total of 403 surveys have been administered to large-herd parlor workers representing 30 dairies in six western US states. Preliminary results indicate 79% of large-herd dairy parlor workers experienced job-related pain in the previous 12-month period. However, only 6.7% reported having a pain that prevented the performance of milking tasks in the previous 12 months, and only 7.1% report seeing a physician to address their job-related pain in the previous 12 months. These findings suggest an underreporting of job-related injuries among large-herd parlor workers. Preliminary data also showed the highest percentages of reported job-related pain are in the feet, upper back, shoulders and wrist. Teat stimulation and cluster attachment are the two most difficult milking tasks. Researchers investigated specific job features associated with the development of job-related pain or injury by asking parlor workers to evaluate the most difficult job features associated with parlor milking on a 0-10 Likert scale. Workers rated “continuing to work when injured or hurt” and “working in hot, cold, wet, humid conditions” as the two most problematic job-features associated with parlor milking.

Muscle Force and Posture Exposures

Full-shift EMG Amplitude Probability Distribution Function (APDF) results revealed mean peak loads of 57.8% of Maximum Voluntary Contraction (MVC) of the flexor forearm musculature and 48.5% of MVC of the anterior deltoid. Full-shift Exposure Variation Analysis (EVA) results revealed 94% of myoelectric activity in both flexor forearm and anterior deltoid musculature was 1 second or less in duration, indicative of highly repetitive activities. Based on studies of muscular endurance during constrained static and dynamic work, Jonsson (1982) recommends muscle contraction force peak loads should not exceed 50% of MVC to reduce risk for muscular injury. Full-shift shoulder posture EVA revealed nearly 40% of the workshift involved the shoulder being elevated greater than 45 degrees. Silverstein (2008) reported upper arm flexion ≥ 45 degrees $\geq 15\%$ of time combined with forceful exertions or forceful pinch to be a significant risk factor for development of rotator cuff syndrome.

Conclusions

The industrialization of dairy production in the US has led to increased occupational risk of the development of musculoskeletal disorders among large-herd parlor workers. Preliminary findings from the current studies suggest large-herd parlor workers may be exposed to upper extremity risk factors (extreme posture, repetition, high muscle loads) associated with the development of musculoskeletal disorders. Continued ergonomic research is needed to further quantify these exposures to facilitate the development of cost-effective ergonomic intervention strategies.

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