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Lower working heights decrease contraction intensity of shoulder muscles in a herringbone 30° milking parlor

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ABSTRACT

Musculoskeletal disorders have been a main concern in milkers for many years. To improve posture, a formula was developed in a previous study to calculate ergonomically optimal working heights for various milking parlor types. However, the working height recommendations based on the formula for the herringbone 30° parlor were broad. To clarify the recommendations for the optimal working height, we investigated the effect of working height on upper limb and shoulder muscle contraction intensities. We evaluated 60 milking cluster attachment procedures in a herringbone 30° milking parlor in 7 men and 9 women. Specifically, we examined the effect of working height on muscle contraction intensity of 4 arm and shoulder muscles bilaterally (flexor carpi ulnaris, biceps brachii, deltoideus anterior, and upper trapezius) by using surface electromyography. The working heights (low, medium, and high), which reflect the ratio of the subject's height to the height of the udder base, were used in the milking health formula to determine and fit individual depth of pits. Data were evaluated for each muscle and arm side in the functions holding and attaching. Statistical analysis was performed using linear mixed effects models, where muscle contraction intensity served as a target variable, whereas working height coefficient, sex, subject height, and repetition were treated as fixed effects, and repetition group nested in working height nested in subject was considered a random effect. Contraction intensities decreased with decreasing working height for the deltoideus anterior and upper trapezius, but not for the flexor carpi ulnaris or the biceps brachii muscles in both holding and attaching arm functions. We found that milking at a lower working height reduced muscle contraction intensities of the shoulder muscles. Women showed higher contraction intensities than men, whereas subject height had no effect. The study demonstrated that a lower working height decreased muscular load during milking. These lower working heights should be used within the recommendations made by the milking health formula for the herringbone 30°. Working heights could be adjusted effectively for milkers of varying body height. Future studies should therefore use the milking health formula as a tool to objectively compare and improve the accuracy of the working height coefficients.
Key words: milking health formula, ergonomics, physical load, electromyography

INTRODUCTION

Milking parlor productivity is extremely important, yet human health should not be neglected in this environment. Due to ongoing reports of high levels of musculoskeletal problems in milking parlor operators (Jakob, 2010; Patil et al., 2012; Douphrate et al., 2013, 2014), research has aimed to evaluate risk factors during milking, such as posture (Jakob et al., 2012; Cockburn et al., 2015; Jakob and Thinius, 2015) and physical load (Liebers et al., 2009). A recent European study reported that 84% of Swedish and 85% of German milkers that work in milking parlors suffered from complaints in one or more body parts (Lunner Kolstrup and Jakob, 2016). Milking personnel has generally been advised to work in a position in which the teat ends are at shoulder level (Jakob et al., 2009, 2012). Liebers et al. (2009) monitored 6 female milkers using surface electromyography and found that light clusters could reduce muscle contraction intensities. Further, they concluded that working at shoulder height would decrease muscular load (Liebers et al., 2009). Contrarily, in a recent study, we found that raising the floor level for the milker would decrease the lifting height and, thus, benefit posture (Cockburn et al., 2015). In the same study, we also provided recommendations regarding differing working heights (**WH**) for a variety of parlor types (autotandem, herringbone 30°, herringbone

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50°, parallel, and rotary) and developed guidelines that were implemented in the milking health formula (Cockburn et al., 2015). These recommendations enabled the calculation of WH under consideration of the parlor type, the cows' mean udder height, and the milkers body height.

The WH recommendations provided by the milking health formula resulted in considerably lower WH than those currently used in a commercial setting, especially for herringbone 30° and side-by-side parlors (Cockburn et al., 2015). Liebers et al. (2009) recommended a WH where the udder is at shoulder level; considering a median male milker of 1.75 m in height with a shoulder height of 1.45 m, this results in a WH coefficient of 0.8 (Lange and Windel, 2013). Furthermore, the recommended WH coefficient for the herringbone 30° parlor was very broad (between 0.7 and 0.9). As, for example, 53% of German farms and 30% of Swedish farms use herringbone parlors (Lunner Kolstrup and Jakob, 2016), it was valuable to gain further information on the correct working heights for this milking parlor type. The lower WH recommended by the milking health formula could be favorable not only in improving posture, but also for reducing muscle contraction intensity and, thus, the physical demand during milking. Therefore, additional information was needed to refine the recommended WH coefficients that had been derived from on-farm experiments for this milking parlor type. Muscular contraction intensities give advanced insight into the effect of physical procedures on the musculoskeletal system. Surface electromyography (**sEMG**) is commonly used to measure these contraction intensities. It has been suggested that static (>10 s) contraction intensities over 5% of the maximum voluntary contraction (**MVC**) must be avoided, and mean contraction intensities should remain below 10% but must remain below 14% of the MVC to prevent long-term damage or injuries (Jonsson, 1978).

The present study aimed to investigate the effect of WH on upper limb and shoulder physical workload by evaluating muscle contraction intensities during the milking procedure. We further expected to improve the precision of the milking health formula's optimal WH coefficient for the herringbone 30° parlor in a laboratory setting. A secondary aim of our study was to investigate the milking health formula's ability to set comparable WH for subjects of different body heights.

MATERIALS AND METHODS

Experimental Setting

The study was carried out in the experimental milking parlor of Agroscope in Tänikon, Switzerland. This experimental milking parlor was a 2 × 5 herringbone 30° parlor with a manure curb of 0.1 m (Figure 1; GEA Farm Technologies GmbH, Bönen, Germany). It was equipped with an adjustable floor and the cluster-positioning arm Posilactor (GEA Farm Technologies GmbH), which allowed for a variation of WH and a steady positioning of the milking clusters. Cluster-positioning arms were used because they help standardize and smoothen the movements between subjects. The milking clusters used were the GEA "Classic 300" (GEA Farm Technologies GmbH) and weighed 2.6 kg. The short milk tubes were made of silicon, which improves handling (Siliconform, Türkheim, Germany).

Subjects were monitored while attaching a milking cluster to an artificial udder (IC KUH, Bad Bentheim, Germany). This udder was placed in a self-constructed wooden stand with an udder base height of 0.55 m (Figure 2). The wooden stand was equipped with true-to-scale hind legs with size proportions that reflected the mean size of cow legs at our research farm. The artificial udders were positioned in the middle of the left and right sides of the milking parlor (milking stalls 3 and 8, Figure 1).

Subjects

The study was registered with the Swiss Ethics Commission of the Canton of Thurgau, Switzerland. Seven men and 9 women with milking experience, but without a daily routine, participated in the trial. Milkers without work routine were chosen to exclude habituated work procedures and, thus, be able to instruct a particular milking cluster attachment technique. All milkers were in good health, had a body mass index below 30, and participated voluntarily. Women measured between 1.68 and 1.89 m (mean 1.76 ± 0.06 m) and men measured between 1.74 and 1.89 m (mean 1.81 ± 0.05 m) in height.

Working Heights

Three WH were individually installed for each subject (Figure 3). These were determined by using WH coefficients, which reflect the ratio of the height of the udder base + depth of pit to the height of the milker (equation 1):

$$\text{Depth of pit (m)} = [\text{subject height (m)} \times \text{coefficient}] - [\text{herd mean udder height (m)}], \quad [1]$$

where the coefficient is calculated as

$$\text{Coefficient} = [\text{udder base height (m)} + \text{depth of pit (m)}]/\text{subject height (m)}.$$