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# Improving ergonomics in milking parlors: Empirical findings for optimal working heights in five milking parlor types

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## ABSTRACT

Milking postures have shifted from seated milking in tethered stalls to milking in a standing position in parlors. However, the musculoskeletal workload of dairy farmers remains high. Previous studies have shown that different working heights affect ergonomics, but they could not objectively evaluate and quantify the workload. The aim of the present study was to assess the effect of working height in different milking parlor types on the milker's workload during the task of attaching milking clusters. Computer-assisted recording and long-term analysis of movements were used to record positions of joints and body regions while performing certain tasks in terms of angular degrees of joints (ADJ) according to the neutral zero method. The 5th, 50th, and 95th percentiles described the distribution of angular degree values measured for each joint. The ADJ were evaluated according to international standards and other scientific literature on the issue to assess the muscular load. The workload was compared between 5 parlor types (auto tandem, herringbone 30°, herringbone 50°, parallel, and rotary) on 15 farms with 2 subjects per parlor and 1 milking period per subject. The working height was defined as a coefficient based on the milker's body height, the floor level, and the cow's udder height. The data recorded during the attachment task were analyzed using generalized linear mixed-effects models taking into account the hierarchical experimental design. The results indicated that the interaction of the cow's udder height, the milker's body height, and the parlor type had a larger effect on ergonomics than each parameter had independently. The interaction was significant in at least 1 of the 3 percentiles in 28 out of 31 ADJ. The postural differences between parlor types, however, were minor. A milking health formula was created to calculate the ideal depth of pit by considering the parlor type, the milker's height, and the mean herd udder height. This formula can be used to develop individual recommendations for future parlor construction.
**Key words:** guideline, milking health formula, posture, workload, herringbone

## INTRODUCTION

Dairy farmers display high levels of musculoskeletal disorders; thus, the present study aimed at analyzing and improving posture during milking. The milking process represents a large part of the daily work routine on dairy farms, and despite position being improved compared with milking in stanchion systems, it has been associated with awkward postures (Jakob et al., 2009). Although milking may not be perceived as strenuous because it has been considered light work for the cardiovascular system (Perkiö-Mäkelä and Hentilä, 2005), several questionnaire-based studies showed that a large percentage of dairy farmers suffer from musculoskeletal problems, particularly disorders associated with the wrists and hands (Stål et al., 1996; Kauke et al., 2010; Kolstrup et al., 2010). Pinzke (2003) reported 83% of men and 90% of women to be affected by such problems, which is in line with Douphrate et al. (2009), who stated that 80% of dairy farmers suffer from musculoskeletal disorders. In addition, Karttunen and Rautiainen (2011) reported a decline in working ability, which was caused by these problems, in 39% of dairy farmers.

Health and efficiency considerations have influenced dairy husbandry in the past. As a consequence of dairy farm automation and industrialization, herd sizes have increased and milking is commonly performed in parlors. Previous research assessed the muscular load of the upper extremities during milking in parlors compared with that during milking in a tethered system and showed that the peak loads in milking parlors were decreased (Stål et al., 2000). Despite the expectation that milking in parlors reduced the physical load, problems in the neck, shoulder, and upper extremities of milkers remained (Arborelius, 1986; Jakob et al., 2012).

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Tuure and Alasuutari (2009) reported that 1 out of 3 milkers who worked in a loose-housing barn were affected by problems in the upper limb, such as the neck and shoulder regions. Previous ergonomic research has focused on assessing the workload of the elbow, shoulder, and hip regions, but results also demonstrated a significant effect on the torsion and side bending of the trunk when milkers had to operate heavy milking clusters (Jakob et al., 2009). Liebers and Caffier (2006) also identified severe strains on the milkers' knees, upper limbs, and lower backs. Specific research investigated the ergonomic benefit of support arms, because milking clusters were lifted in a static posture and could weigh up to 3 kg, yet surprisingly little effect was seen (Stål et al., 2003). Conversely, the distance between the udder and the milker has been reported to cause a leverage action of up to 9 N·m, indicating a high muscular load during the attachment task (Jakob et al., 2007). Pinzke et al. (2001) described the attachment task as the most strenuous task, because it involved the lifting and attaching of the milking cluster. Furthermore, Kauke et al. (2010) reported that 14% of survey participants perceived cluster attachment to be most strenuous. These results were in line with other international studies that indicated that the attachment task negatively affected ergonomics (Stål et al., 1996, 2003; Jakob et al., 2012). Whereas all tasks during milking were carried out in the udder region, and thus the working height was relatively similar, the attachment task was particularly interesting, as the milker spent 0.2 min/cow and milking procedure on attaching the milking cluster (Schick, 2000). During this period of time, the milker had to lift the cluster, which weighed between 2.6 and 3.1 kg, to the udder base; thus the task is physically more demanding than other tasks carried out during milking, such as premilking, stimulation, swiveling the milking cluster, or dipping or spraying the teats.

Ergonomics during milking were determined by multiple factors, such as parlor type, cow dimension, udder base height, parlor height, and milker height, and were linked strongly to the horizontal distance between the cow and the milker (Jakob et al., 2009). Of the few studies that have assessed the ergonomic differences in milking parlor systems, Stål et al. (2003) reported improved wrist positions in rotary systems compared with herringbone and tethered systems, indicating ergonomic differences between parlor types. Results from early studies suggested that ergonomics could be improved when floors were adjusted to a height at which the milker's elbows were considered to be at an ideal level during the working procedure (Billon et al., 1985; Stål and Pinzke, 1991). Jakob et al. (2012) further stated that muscle activity was lowest when light milking clusters were used and the teat ends were at shoulder level. Hence, some parlors were equipped with adjustable floors to enable ideal ergonomic posture for milkers of different heights. However, studies have shown that udder base height varies between 22 and 69 cm (Jakob et al., 2009), with a mean of 56 cm depending on the age and breed of the cows (Jakob, 2011). Jakob et al. (2009) reported that such factors could cause a variation of the ideal floor height for good posture of up to 50 cm. Furthermore, Billon (2009) found that the ideal depth of pit could vary between parlor types and advised that pits in parallel parlors should be higher than other pits. Tuure and Alasuutari (2009) further indicated differences between parlor types, as they reported horizontal reaching distance in herringbone 30° (**HB 30°**), autotandem (**ATD**), and parallel (**PAR**) parlors to vary between 36 and 58 cm. As body heights vary between milkers, a practical guide is needed for adjusting floors to the ideal working height at which the milker can work in an optimized ergonomic posture. Research, therefore, needs to identify methods to improve ergonomics in milking parlors to reduce the negative effect of milking postures on the musculoskeletal system of milkers. The present study aimed to analyze ergonomics in different milking parlor types and develop individual recommendations on working heights to improve posture in a variety of milking parlors.

## MATERIALS AND METHODS

### *Body Posture Recording with the CUELA System*

Computer-assisted recording and long-term analysis (**CUELA**) was used to record musculoskeletal motions. The CUELA system has been used to assess ergonomics in different professions, such as nursing (Freitag et al., 2007) and flight attendance (Glitsch et al., 2007), and in several work environments, such as visual display unit workplaces (Ellegast et al., 2012b), places that require the pulling and pushing of waste containers (Backhaus et al., 2012), offices (Ellegast et al., 2012a), and animal facility washrooms (Kiermayer et al., 2011). Additionally, the CUELA system was validated in a milking parlor environment during a feasibility study (Kauke et al., 2009).

The CUELA system uses movement sensors (ADXL 3D accelerometers 103/203, Analog Devices, Norwood, MA; and muRata ENC-03R gyroscopes, Murata, Tokyo, Japan) to record the inclination and torsion of joints. Positions of joints are recorded in terms of angular degrees of joints (**ADJ**) according to the neutral zero method (Ryf and Weymann, 1995). The system further records how long each posture is maintained (Ellegast, 1998).