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The effects of working height and manipulated weights on subjective strain, body posture and muscular activity of milking parlor operatives – Laboratory study

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ABSTRACT

The incidence of work-related musculoskeletal disorders among milking parlor operatives has increased while milking parlors were getting bigger. At the same time parlor design was improved regarding the physical load as well as body postures.

In contrast to former studies on workload in parlor milking this project was designed and performed as an experimental study in a laboratory setting including 6 female subjects. Motion analysis and psychophysiological analysis (EMG, heart rate, subjective perceived strain index) were carried out. Intra-individual comparisons were made for the different settings using general linear models for repeated measurements. The effects of working height and weight of milking unit during parlor milking were investigated regarding the impact on muscular load and body posture. The results showed that the optimal working height for attaching the cluster is having the teats at shoulder level of the parlor operative. Another important workload reduction was achieved by reducing the weight of the milking cluster.

The named discomfort, localized fatigue and the body posture analysis provide evidence that the changes in modern milking parlors due to mechanization still bear the risk of overburden for the worker.

1. Introduction

In most countries, agriculture is recognized as one of the most hazardous industries, with musculoskeletal disorders (MSDs) being the number one problem workers are suffering from (Fathallah, 2010; Niu, 2010). Although physical risk factors are major contributors to MSDs in agriculture, others like psychosocial, organizational or socio-economic factors may be important to monitor for successful prevention of the named disorders. This paper is focusing on dairy farming and especially on milking parlor operatives.

Over the past decades the structure of the global dairy industry has changed. The incidence of symptoms in the neck, shoulder and upper extremities among milkers is an ongoing problem noticed all over the world although the expectations were to reduce them by reducing the. physical load in modern parlors (Arborelius et al., 1986).

A recent investigation with self-administered questionnaires in Iowa (USA) suggested approximately 80% of dairy farm workers may experience musculoskeletal symptoms (Douphrate et al., 2009). Using the Work Ability Index (WAI) to study full-time dairy farmers, Finnish researchers reported a declined work ability of 39% overall and 44% among females (Karttunen and Rautiainen, 2011). The most common disease was MSD and which contributed to declined work ability.

The evaluation of temporary disability data in Germany has shown a higher rate of work absenteeism for female milking parlor operatives in comparison to the whole employed population. Diagnosis related to disorders of the upper limb like enthesiopathies, shoulder lesions and carpal tunnel syndrome, but also disorders of the lower back (dorsalgia) and of lower limbs (knee osteoarthritis and meniscopathia) were the most prevalent (Liebers and Caffier, 2006, 2009). The age standardized morbidity ratios (SMR) of the number of cases of sick leaves in comparison to the whole German employed population ranged between 2.1 for enthesiopathy and 1.4 for back aches (Liebers and Caffier, 2006). In 2008, 4025 men and 3505 women were employed as milkers (occupational group “042” according to the German classification of occupation).

According to a recent Finnish study almost one out of three milk producers who had a new loose housing barn experienced symptoms in the neck-shoulder region often or almost all the time (Tuure and Karttunen, 2007).

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Several Swedish studies also showed a high prevalence of work-related MSD among dairy farmers as compared to reference data from other occupations. Additionally, females reported symptoms in the hands and wrists (Stål et al., 1996, 1997).

Increased working time, more cows milked per hour, more milking units per parlor and the highly repetitive working routine were possible risk factors associated with musculoskeletal symptoms (MSS) (Pinzke, 2003).

Due to the structural developments in agriculture, milking in separate milking parlors has become the most common system as well as being the future perspective. Herd sizes are increasing whereas the number of dairy farms is decreasing globally. Large-scale milk production increases the time spent performing tasks such as attaching the cluster which was shown to bear a manifest risk to the forearm (Stål et al., 2003a, 1999). The structural and technical developments of the past 30 years have therefore not contributed to reduce the rate of MSD among dairy farmers and milking parlor operatives respectively although the physical load was reduced. The remaining manual work operations often involve lifting of equipment, awkward working postures and high repetitions, all of which are general risk factors for back injuries and other musculoskeletal disorders (Bernard, 1997; da Costa and Vieira, 2010). The strong association between high physical workload due to these factors, the risky tasks and work practices on the one hand and the occurrence of higher rates of musculoskeletal disorders on the other hand are well known for many jobs in the agricultural industry and especially found for milking parlor operatives (Kirkhorn et al., 2010).

Regarding the work flow milking increasing herd sizes is characterized by task specialization resulting in reduced rest times (Douphrate et al., 2009). Higher cow throughput rates increase the physical workload.

Recent workload assessment studies among milking parlor operatives have been conducted (Pinzke et al., 2001; Stål et al., 2003a,b; Kauke et al., 2009). These studies have been task specific, with minimal emphasis on workspace design such as milking pit height worker body dimensions such as height or cow dimension such as udder height. Stål et al. (2003a) reported a high work intensity associated with milking in rotary parlors with increased physical demands on the wrists and hands. Results from a recent Finnish study suggested parlor dimensions are crucial in reducing physical (Tuure et al., 2009). This study focused on the horizontal reaching distance between the worker and the udder.

Our study focused on the influence of working height and the milking unit weight. In practice the situation for the worker changes from cow to cow (see Fig. 1). The range of variation in the udder position in relation to the worker's shoulder depends on worker height vertical distance between udder and floor, horizontal distance between udder and edge of milking pit and height of the milking pit where the worker stands. The distance between the bottom of the udder and the milking floor ranges from 40 to 70 cm in an average Holstein Frisian cross breed herd. There is an additional 30 cm of body height variation between the 5th female and the 95th male percentile. The shoulder height of workers could range from 124 cm (5th female percentile) to 154 cm (95th male percentile). The horizontal distance is mainly influenced by the parlor type and cow morphology. Tuure and Alasuutari (2009) reported a range of the horizontal distance between 36 and 58 cm for three different parlor types (30° herringbone, side-by-side, auto tandem).

The aim of the study was to investigate to what extent physical strain and exertions as well as body kinematics of employees (outcomes) are influenced by different working heights and weights of milking units (exposures) during attachment. Ergonomic recommendations for milking pit height and milking unit weights will be made based on research findings.

The background of this study is the assumption that varying parlor designs regarding working height (equals the depth of the alley plus udder height) and design, handling and weight of the milking unit measurably influence the work process. Therefore the work flow (time expense, kinetic behavior), physical strain (EMG, cardiovascular parameters) and the subjective perceived strain (Borg scale) of milking parlor operatives were measured.

2. Material and methods

2.1. Test procedure

The study was performed in a laboratory setting (see Fig. 2) using an artificial udder to be able to control and adjust different working heights. Wooden platforms were used to change the floor height. For each person the udder height at teat ends was individually adjusted 15 cm above, at and 15 cm below shoulder level (see Table 1).

The milking parlor design was identical to a 30° herringbone parlor. Vacuum suction pressure was applied to maintain teat cups attachment to the artificial udder. Apart from the working heights two different milking units were tested. A light milking cluster weighed 1.4 kg and a heavier cluster weighed 2.4 kg. Six settings (3 heights × 2 weights) were repeated 15 times each by all subjects. The sequence of the six experimental settings was systematically changed between the subjects to avoid sequence effects. The sequences were predefined in the study protocol, systematically considering the six possible combinations of the order of the three working heights (ABC, ACB, BCA, CAB, BAC and CBA). The first subject was assigned to the first sequence, the second subject to the second sequence and so on.

The duration of the 15 repetitions within a setting was fixed to 1 min assuming an hourly throughput rate of 60 cows (duration of a setting: 15 × 1 min = 15 min). Within the duration of one repetition the worker had to attach the milking cluster and take it off after half a minute. The time in between two cycles takes approx. 10 min (technical preparation of the settings) and was free to recover for the subjects. The process of attaching the cluster included the work elements grabbing the milking unit with the left hand and holding it beneath the udder while the right hand was attaching cup by cup to the teats.

2.2. Subjects

Six experienced, professional female milkers were included in the measurements. All subjects used different milking units in their

Fig. 1. Example of natural variation in udder height mainly depending on age.