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# Analysis of Postural Load During Tasks Related to Milking Cows—A Case Study

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*The aim of this study was to analyse postural load during tasks related to milking cows of 2 farmers on 2 different farms (one with a manual milk transport system, the other with a fully automated milk transport system) as a case study. The participants were full-time farmers, they were both healthy and experienced in their job. The Ovako Working Posture Analyzing System (OWAS) was used to evaluate postural load and postural risk. Postural load was medium for the farmer on the farm with a manual milk transport system and high for the farmer working on the farm with a fully automated milk transport system. Thus, it can be concluded that a higher level of farm mechanization not always mean that the farmer's postural load is lower, but limitation of OWAS should be considered.*

postural load  milking cows  case study

## 1. INTRODUCTION

Statistics indicate that there are more than 24 million dairy cows in the European Union [1], so milking cows is a representative tasks for the agriculture sector. Trying to illustrate the magnitude of a farmer's work, it should be mentioned that production of cows' milk in 2009 exceeded $12 \cdot 10^9$ L. In Poland, average annual milk yield from one cow was 4455 L [2]. Milking one cow does not take more than ~10 min. However, in a large herd milking takes several hours per day. This can create risk for development of musculoskeletal disorders (MSDs) in farmers'. Milking tasks differ depending on the availability of up-to-date milking installations, which means that risk depends on the level of automation of the farm.

Musculoskeletal disorders are an important problem among other employees in agriculture, too. Several studies reported high incidence of work-related musculoskeletal disorders of the upper limbs in workers in agriculture [3, 4, 5].

In Poland, in the first quarter of 2010, there were almost 2 000 000 employees working in the agriculture sector, most of them (1 845 000) on private farms [6]. About 49% of people working in agriculture reported general tiredness, 50.5% experienced muscle pain and 50.5% complained of back pain [7].

OWAS (Ovako Working Posture Analyzing System) [8, 9] was used in many studies on MSDs risk assessment in numerous occupations, such as constructors [10], females employed on dairy farms [11], persons employed in fruit production [12], planting in forestry [13] or employees on a poultry farm [14]. It was also introduced by Nevala-Puranen, Kallionpää and Ojanen [15] and Navala-Puranen, Taattola and Venäläinen [16], who analysed milkers' musculoskeletal load; their

This paper was based on the results of the European Commission DG Employment, Social Affairs and Equal Opportunities project "Good practices in agriculture: social partners participation in the prevention of musculoskeletal disorders" and a research task carried out within the scope of the first stage of the National Programme "Improvement of safety and working conditions" partly supported in 2008–2010 — within the scope of state services — by the Ministry of Labour and Social Policy.

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results indicated simultaneous awkward body posture (bent and twisted) during up to 29% of their working time in a stanchion barn.

Despite an increased level of mechanization and automation, farm work involves several physically demanding tasks. Many tasks in agriculture are associated with lifting, carrying heavy loads, awkward work postures, repeated movements and vibrations [17, 18, 19, 20, 21, 22, 23, 24, 25]. This makes farming an occupation with a high risk of developing of musculoskeletal disorders and work-related disabilities [26, 27, 28].

Mechanization is remodelling types of tasks in agriculture, so it is important to examine if it decreases risk. Therefore, the aim of this study was to analyse postural load during tasks related to milking cows of two farmers on two diffrent farms. The case study refered to a farm with a manual milk transport system, which imposed on the farmer carrying milk in barrels and pouring milk into a cooler tank and to a farm with a fully automated milk transport system, where milk was transported in the pipelines into a cooler tank.

## 2. MATERIAL AND METHODS

### 2.1. Material

The analysis was performed on two farms with different level of automation. Those farms rely on the milk transport system. The participants were full-time farmers, who were both healthy and experienced in their job. Milking cows on their farms was their permanent job. The farmer working on the farm with a manual milk transport system was 27 years old and had been doing this job for 10 years. There were 20 cows in the herd. In this farm, animals browsed on a pasture all day; they were driven into a barn for milking only.

The farmer who worked on the farm with a fully automated milk transport system was 40 years old and had spent 22 years in this job. The farm consisted of 25 milking cows; however, for the analysis tasks related to milking 20 cows were considered (the same number of cows as on the other farm). The farmer working on the farm with a fully automated milk transport system milked all cows on the farm on his own. In this farm, cows stood in a barn all the time. The type of cowshed was tied barn (tie stalls). The pipeline milking system transferred milk from a milking machine to a milk storage.

### 2.2. Methods

OWAS was used to evaluate postural load and risk of MSDs development [8, 9]. The momentary observations of postures at certain intervals of the evaluated work create the basis for analysis. Each momentary observation relates to one performed task characterised by posture and the value of force. Codes are assigned to each task posture and force.

For each task the observed combinations of specific body parts (back, arms and legs) and exerted force are grouped in one out of four categories of workplace evaluation and workplace improvement recommendations. Risk is estimated in three-level risk evaluation system (low, medium, high) (Table 1).

The work tasks with the same codes of body postures for back, arms, legs and force are not only marked by the same category of load, but according to OWAS method create the same postural load. It means that momentary observations of specific work tasks with the same the body posture codes and force codes create the same load, which means that time of those tasks can be summarised. Therefore, all tasks with the same four-digit code can be integrated and marked as one task. Such procedure usually reduces number of tasks.

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The tasks of farmers' milking cycle were analysed. Task activities were separated and afterwards OWAS codes of body posture were assigned for each task. The force exerted during each task was also evaluated. The next step was the identification of categories on the basis of the codes, followed by risk evaluation for each task.

**TABLE 1. Interpretation of the Results of Static Load Evaluation**

| OWAS Category | Working Time (%) | Body Posture | Risk/Workload |
|---|---|---|---|
| 1 | <70 | C/NC | low |
| | >70 | | medium |
| | <50 | C | low |
| | 50–70 | | medium |
| | >70 | | high |
| 2 | <50 | C/NC | low |
| | 50–70 | | medium |
| | >70 | | high |
| | <30 | C | low |
| | 30–50 | | medium |
| | >50 | | high |
| 3 or 4 | <30 | C | medium |
| | >30 | | high |

*Notes.* OWAS—Ovako working posture analyzing system, C—constrained, NC—not constrained.

## 3. ANALYSIS OF POSTURAL LOAD

### 3.1. Milking on the farm with a manual milk transport system

Farmer A and members of his family on the farm with a manual milk transport system worked. However, the milking tasks were done only by the farmer. For the analysis only morning milking tasks were considered. The whole herd was milked in one milking cycle of 253 min. Measurements took place in the seasonal time when the cows were on pasture during the day and night and brought to barn only for milking. Table 2 presents the farmer's activities (tasks) during milking a herd of 20 cows and working time for each task.

**TABLE 2. Chronometrics of Working Time: Farmer A**

| Task | Work Activites | Time (min) |
|---|---|---|
| 1 | driving cows from pasture into barn | 30.0 |
| 2 | preparing milking equipment, folding milking machine, turning on pump, cleaning milking machine | 10.0 |
| 3 | milking, which consists of | |
| 3a | cleaning udders | 8.3 |
| 3b | connecting milking machine | 13.3 |
| 3c | milking cow, massaging udders | 40.0 |
| 3d | observing milk flow | 80.0 |
| 3e | disconnecting milking machine | 1.7 |
| 4 | emptying barrel, which consists of | |
| 4a | walking to milking tank room with milking machine | 10.0 |
| 4b | pouring out milk | 20.0 |
| 4c | walking to barn to next cow | 9.5 |
| 5 | driving cows from barn to pasture | 30.0 |

Many tasks related to milking cows were performed in squat body posture (Figure 1), which was uncomfortable and could create fatigue. This body posture was adopted during such tasks as cleaning udders (3a), connecting a milking machine (3b), milking a cow, massaging udders (3c) and disconnecting a milking machine (3e). Tasks related to milking cows, which involved pouring milk from a barrel to a milk collector (Figure 2), required lifting a heavy barrel with milk (25 kg). Doing this task, the farmer exerted high muscle strength by upper limbs. Lower back was exposed as well. Table 3 presents codes according to OWAS method of body postures, codes of force and OWAS category with percentage of working time of each task, which appeared during milker work.

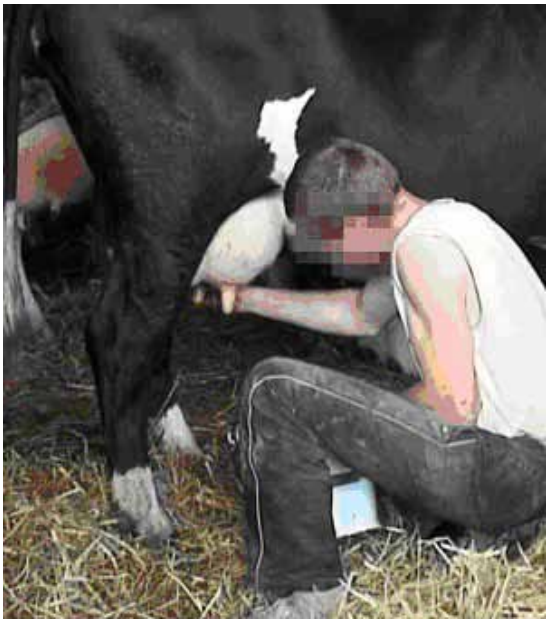

**Figure 1. Cleaning a cow's udders and preparing tasks for milking it.**

**TABLE 3. OWAS Codes by Task: Farmer A**

| Task | Work Activites | Body Posture Code | | | Force Code | OWAS Category | Body Posture | Time (%) |
|---|---|---|---|---|---|---|---|---|
| | | Back | Arms | Legs | | | | |
| 1 | driving cows from pasture into barn | 1 | 1 | 7 | 1 | 1 | NC | 11.9 |
| 2 | preparing milking equipment, folding milking machine, turning on pump, cleaning milking machine | 2 | 1 | 2 | 1 | 2 | NC | 4.0 |
| 3a | cleaning udders | 2 | 1 | 4 | 1 | 3 | C | 3.3 |
| 3b | connecting milking machine | 2 | 1 | 4 | 1 | 3 | C | 5.3 |
| 3c | milking cow, massaging udders | 2 | 1 | 4 | 1 | 3 | C | 15.8 |
| 3d | observing milk flow | 1 | 1 | 2 | 1 | 2 | NC | 31.6 |
| 3e | disconnecting milking machine | 2 | 1 | 4 | 1 | 3 | C | 0.7 |
| 4a | walking to milking tank room with milking machine | 1 | 1 | 7 | 3 | 1 | NC | 4.0 |
| 4b | pouring out milk | 1 | 2 | 2 | 3 | 1 | NC | 7.9 |
| 4c | walking to barn to next cow | 1 | 1 | 7 | 1 | 1 | NC | 3.8 |
| 5 | driving cows from barn to pasture | 1 | 1 | 7 | 1 | 1 | NC | 1.9 |

*Notes*. OWAS—Ovako working posture analyzing system, C—constrained, NC—not constrained.

**Figure 2. Pouring milk from a barrel to a milk container.**

According to the analysis procedure, the tasks with the same codes of body postures (back, legs and arms) and force from Table 3 were integrated with the total time related to each task (Table 4). The integration made it possible to decrease the number of tasks from 11 to 6. Table 4 presents risk assessment for the farmer working on the farm with a fully automated milk transport system regarding the six tasks.

Most tasks performed during most working time created a low postural load. One of the tasks is characterised by medium risk. Therefore, total postural risk is also assessed as medium. The medium risk of postural development resulted from a squat posture during connecting, disconnecting a milking machine to cow's udders, cleaning udders and massaging udders during milking.

It is important to note that farmer A carried loads of over 20 kg during 11.9% of his working time during carrying barrels with milk to a milk container (tasks 4a) and pouring milk into a container (task 4b) (Tables 2–3).

The analysis of OWAS categories related to tasks performed by farmer A (Table 4) showed that the category of four tasks was classified as 1 (tasks number after integration: I, II, III, IV), one task (V; the number of the task after integration) was classified as 2 and one task as 3 (VI).

The most frequent body posture (taking 31.6% of the working time) during work on the farm with a manual milk transport system was standing with a straight back, legs and with both arms below the shoulders, without load (OWAS

**TABLE 4. Final Evaluation of Postural Load: Farmer A**

| Task After Integration | Body Posture Code | | | Force Code | OWAS Category | Body Posture | Time (%) | Risk |
|---|---|---|---|---|---|---|---|---|
| | Back | Arms | Legs | | | | | |
| I | 1 | 1 | 2 | 1 | 1 | NC | 31.6 | low |
| II | 1 | 1 | 7 | 1 | 1 | NC | 27.5 | low |
| III | 1 | 1 | 7 | 3 | 1 | NC | 4.0 | low |
| IV | 1 | 2 | 2 | 3 | 1 | NC | 7.9 | low |
| V | 2 | 1 | 2 | 1 | 2 | NC | 4.0 | low |
| VI | 2 | 1 | 4 | 1 | 3 | C | 25.0 | medium |
| | | | | | | | total risk | medium |

*Notes*. OWAS—Ovako working posture analyzing system, C—constrained, NC—not constrained.

category 1). The study showed that straight back posture constituted 71% of the working time of the farmer working on the farm with a manual milk transport system and for 29% of the farmer's working time his back was bent. The arms of the farmer working on the farm with a manual milk transport system were above shoulder level 7.9% of working time.

### 3.2. Milking on the farm with a fully automated milk transport system

On the farm with a fully automated milk transport system, the cows were milked twice a day; however, only the morning cycle of milking was analysed. Time needed for milking 20 cows was 100 min in one milking cycle. Two milking machine units were available for milking at the same time. The use of a pipeline milking system prevented the need to carry heavy loads, as churns may contain 25 kg of milk. Walking with full churns and pouring milk from a churn to a container was completely eliminated. Table 5 presents chronometrics of a farmer working on the farm with a fully automated milk transport system (farmer B).

**TABLE 5. Chronometrics of Working Time: Farmer B**

| Task | Work Activities | Time (min) |
|---|---|---|
| 1a | preparing milking equipment: walking | 2 |
| 1b | preparing milking equipment: standing | 8 |
| 2 | milking, which consists of | |
| 2a | cleaning udders | 15 |
| 2b | connecting milking machine | 3 |
| 2c | milking and massaging udders | 35 |
| 2d | observing milk flow | 10 |
| 2e | disconnecting milking machine | 2 |
| 2f | walking to next cow | 25 |

Table 6 presents OWAS codes of body postures, codes of force and OWAS category with percentage of working time by each task. The farmer working on the farm with a pipeline milking system did not carry loads heavier than 10 kg at all (Table 6).

Carrying barrels with milk was completely reduced due to the pipeline system. The work postures in milking differed due to

**TABLE 6. Codes According to Method OWAS by Task: Farmer B**

| Task | Work Activities | Body Posture Code | | | Force Code | OWAS Category | Body Posture | Time (%) |
|---|---|---|---|---|---|---|---|---|
| | | Back | Arms | Legs | | | | |
| 1a | preparing milking equipment: walking | 1 | 1 | 7 | 1 | 1 | NC | 2 |
| 1b | preparing milking equipment: standing | 1 | 1 | 2 | 1 | 1 | NC | 8 |
| 2 | milking, which consists of | | | | | | | |
| 2a | cleaning udders | 2 | 1 | 4 | 1 | 3 | C | 15 |
| 2b | connecting milking machine | 2 | 1 | 4 | 1 | 3 | C | 3 |
| 2c | milking and massaging udders | 2 | 1 | 4 | 1 | 3 | C | 35 |
| 2d | observing milk flow | 1 | 1 | 2 | 1 | 1 | NC | 10 |
| 2e | disconnecting milking machine | 2 | 1 | 4 | 1 | 3 | C | 2 |
| 2f | walking to next cow | 1 | 1 | 7 | 1 | 1 | NC | 25 |

*Notes.* OWAS—Ovako working posture analyzing system, C—constrained, NC—not constrained.

**TABLE 7. Final Evaluation of Postural Load: Farmer B**

| Task After Integration | Body Posture Code | | | Force Code | OWAS Category | Body Posture | Time (%) | Risk |
|---|---|---|---|---|---|---|---|---|
| | Back | Arms | Legs | | | | | |
| I | 1 | 1 | 2 | 1 | 1 | NC | 18 | low |
| II | 1 | 1 | 7 | 1 | 1 | NC | 27 | low |
| III | 2 | 1 | 4 | 1 | 3 | C | 55 | high |
| | | | | | | | total risk | high |

*Notes.* OWAS—Ovako working posture analyzing system, C—constrained, NC—not constrained.

mechanization level, between stanchion barns and parlours.

Table 7 presents a final evaluation of postural load, which appeared during milkers' work. Due to analysis procedure tasks 1b and 2d were integrated into one with the total time related to each category of load and marked as I. Tasks 1a and 2f were marked as II; tasks 2a, 2b, 2c and 2e as III. It means that eight categories of load during work of milker working on the farm with a pipeline milking system were aggregated into three. During most of the farmer's working time (55%) the postural load was of category 3 according to a squat body posture during connecting a milking machine, disconnecting a milking machine, cleaning udders, milking and massaging udders during milking. The farmer's remaining working time (45%) resulted in category 1 and low postural load.

An analysis of the OWAS category of the farmer working on the farm with a fully automated milk transport system (Table 7) showed that two task categories were classified as 1 (I and II) and one task category was classified as 3 (III). The task that was evaluated as high (III, the number of the task after integration, crouching) constituted 55% of the farmer's working time, what meant that it was the most frequent body posture and load during whole working time.

Farmer B had his back straight for 45% of his working time and bent forward for 55% of his working time. The arms of the farmer working on the farm with a fully automated milk transport system were all the time below shoulder level.

High risk was created by task III, which presented OWAS category 3 and lasted 55% of the working time, which resulted in a high risk of MSDs development.

## 4. DISCUSSION

The aim of this study was to analyse postural load during tasks related to milking cows of two farmers on two different farms (a farm with a manual milk transport system and a farm with a fully automated milk transport system) as a case study. Risk of MSDs development for both farmers was evaluated with the use of the well-known and commonly used OWAS method.

After integration, six tasks were separated in the case of the farmer working on the farm with a manual milk transport system (Table 4) and only three tasks in the case of the farmer working on the farm with a fully automated milk transport system (Table 7).

The postural load of farmer A was medium (Table 4); however, five tasks (I, II, III, IV, V) of category 1 and 2 lasting 75% of shift time were evaluated as low and one task (VI) as medium. The medium postural load (risk of MSD development) was caused by constrained body posture with OWAS category 3, with the percentage of working time of 25%. For the same category with only over 30% of working time, the postural load (risk) would be evaluated as high.

The postural load of farmer B was high (Table 7). Two tasks of category 1 were evaluated as low risk (I, II) and one task, of category 3, as high (III). The high risk of postural disorders development was strongly influenced by a high percentage of working time (55%) with constrained body posture causing OWAS category 3.

In Nevala-Puranen et al.'s study, farmers worked with a straight back for 85% of their milking time in parlours [15] and 1% of their time was spent with their back bent forward and

twisted simultaneously [15]. The corresponding values for work in stanchion barns were 40% and 29%, respectively [16]. One or both arms were found to be at or above shoulder level in 24% of the work time in parlours [15], compared with ~18% in stanchion barns [16].

Both farms in the present study were stanchion barns, only the milk transport systems were different. Comparing the percentage structure of body posture with a straight back, the present study results of farmer A were similar to previous studies of Nevala-Puranen et al. [15, 16] in a stanchion barn, with the values of 45% in present study and 40% in Nevala-Puranen's et al.'s study [15]. The percentage structure of time of farmers working with a straight back and working on farm with a manual milk transport system was similar to Nevala-Puranen et al.'s results, where 85% of the working time of a farmer working on a farm with parlours milking system and comparing with our results 71% of working time of farmer working on farm with manual milking system, but 45% of working time of the farmer working on pipeline milking system. Neither farmer in the present study bent back forward and twisted simultaneously as gave Nevala-Puranen et al. in their study. Both farmers bent their back forward, with 29% of working time of farmer A and with 55% of working time of farmer B.

Despite shorter time needed for milking the same herd of cows (100 min needed by farmer B and 253 min needed by farmer A), the postural load was higher. Farmer B could milk more cows in 8 h, but his postural load related to milking one cow was higher due to an awkward body posture during 55% of his working time (crouching body posture when milking 20 cows).

Regarding the body posture with one or both arms above shoulder level Nevala-Puranen et al.'s results presented 24% of working time in parlours [15] and ~18% in stanchion barns [16], although the present results were lower at 7.9% of working time on the farm with a manual milk transport system and completely eliminated on the farm with a pipeline milking system.

A significant part of the analysed tasks created a low postural load, which constitutes 75% of the working time of the farmer working on a farm with a manual milking system and 45% of the working time of the farmer working on a farm with a fully automated milk transport system; however, the total postural risk was medium or high. The medium and high postural risk was caused by an awkward, crouching body posture during connecting and disconnecting a milking machine, which decided on the total evaluation of postural risk (OWAS category 3). Comparing OWAS category 3 of both farmers (Tables 4 and 7), it was important to note that only the time percentage of the farmer on a farm with a fully automated milk transport system was higher and that was the reason of a high risk of MSD development. In the same category, but in the case of shorter time percentage (under 30%), the risk would be evaluated as medium (similar as for the farmer on a farm with a manual milking system). Unfortunately, in the existing milking system on analysed farms, awkward, a crouching body posture cannot be completely avoided.

The higher level of mechanization on the farm resulted in higher work productivity, which means that the same amount of work is done in a shorter time. Mechanization reduced tasks related to carrying heavy load, e.g., carrying heavy barrels with milk to a milk container and pouring milk from a barrel to a container. Mechanization to some extant forced rapid pace of work. The total postural load of a farmer also depends on the types of tasks that the farmer was doing during the rest of his working time. It is important to organise work and plan a production line to reduce awkward body posture.

Although both farms had stanchion barns, the cows stood all the time in the barn on the farm with a manual milk transport system and were brought to the barn only for milking on the farm with a pipeline milking system. Mechanization was on this specific level and with a applied pipeline milking system. Higher level of mechanization could reduce postural load only if it were related to a change in body posture from crouching to standing.

Some simple solutions can partially reduce the load. Although it is possible to decrease postural risk from medium or high to low, this would involve high financial costs and a change of

milking system (e.g., to a herringbone parlour, rotary or automated milking system). The most important thing on both farms and, generally, on most Polish farms is to change the body posture from crouching to standing during milking and related tasks.

A simple solution to reduce musculoskeletal load of the farmer working on the farm with a manual milk transport system is to improve his body posture during milking (Tables 5–6). Examples would be changing a body posture during (2a) cleaning udders, (2b) connecting a milking machine, (2c) milking and massaging udders and (2e) disconnecting a milking machine by using small bucket as a chair or a small chair on a belt worn around the milker's hips, which could change the body posture from a back bent forward to a straight one.

## 5. LIMITATIONS

The main limitation of the study lies in the fact that only two farmers were studied. It could be interesting to take measurements of a group of people in the same conditions on the same farm. This would be a basis for proper statistics and more reliable comparisons.

OWAS is an observational method, which is not very precise. Relatively different body posture causing in reality different postural load are evaluated as the same, marked with the same code. Similar remarks refer to force assert. This means that the method should be considered a preliminary evaluation.

## 6. SUMMARY

The postural risk was medium for farmer A and high for farmer B. This indicates a disadvantage of OWAS, which is simple and does not consider the work speed or freqency of body posture changing. It seems that the force does not have enough substance in OWAS as the work activities where there was a high load of back and arms during carrying barrels with milk and lifting a milk barrel during pouring milk with arms above a shoulder level were given OWAS category 1 with low postural load. That is why OWAS should be recommended only for body posture evaluation and should be considered a preliminary evaluation.

Our analysis showed that the workload on a more mechanized farm can be higher than on a nonmechanized farm, even though it is more efficient. The farmer on the more mechanized farm completed his work (milking cows) in a shorter time, but according to OWAS with a component of higher postural load. The most loaded body parts are lower back and knees. These parts are the most frequent musculoskeletal problems and the sources of pain for farmers.

To reduce musculoskeletal load it is suggested to frequently change the body posture during milking, since not only adopted body postures and support devices have an impact on musculoskeletal load, but time and work organization play a significant role, too.

It can be concluded that the higher level of farm mechanization does not always mean a lower farmer's workload. Mechanization on its own does not always reduce postural load.

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