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ASSESSMENT OF WORKLOAD ON MUSCULOSKELETAL SYSTEM OF MILKERS IN MECHANICAL MILKING THROUGH THE USE OF JOB STRAIN INDEX METHOD

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Abstract

During the last years, as a result of the technological development, farming started to include new solution like a machinery or other devices. However, it has also led to the emergence of new risk factors for which agricultural workers are not often well prepared. In fact, moreover to common occupational hazards, farmers can now face specific risk connected with many various tasks performed in farms. Workers in the agricultural sector are exposed to various risk factors such as manual lifting and handling loads, milking or tractor driving. Based on these circumstances the studies were conducted where the main objective was to investigate a workload during milking. The analysis was conducted on 20 farmers in their own farms during the morning and evening milking with the herringbone and carousel milking systems. The analysis of muscle load was conducted with Job Strain Index method. The JSI is a tool used to evaluate the risk level of a job for developing a disorder of the hand, wrist, forearm or elbow. The highest values of muscle tension and force were observed in the forearm muscles during the attachment of teat cups to the udder. The research shows that the milking work in the herringbone parlour generates a higher risk of problems to the musculoskeletal system of the milker.

Key words**:** *agriculture, milking, musculoskeletal system, work load*

INTRODUCTION

Data from the European Agency for Safety and Health at Work shows that disorders of the musculoskeletal system are the most common diseases in the European Union. Among European workers around 25% complain of backache, about 23% of the respondents complain of muscle pain. Many diseases of the musculoskeletal system which get reported in Poland recently constitute 25% of all occupational diseases [1]. In Polish farming, for example, several dozen fatal accidents occur every year and a number of different kinds of problems closely related to the performed work are recorded [4].

It is therefore necessary to make a thorough approach to the subject of load imposed on musculoskeletal system in attempt to shape appropriate - physical and psychosocial working conditions for farmers. No analysis of the dynamic workload of Polish farmers using electromyography or Job Strain Index method has been carried out to date. The methods allow for a very precise analysis of the load imposed on the human movement system over consecutive operations [2]. Milking of cows is a very good example of the farmers' work that can be precisely analysed. It is featured by a high frequency of repetitions, distinctive body posture of the milker during subsequent operations wrists and hands are positioned during subsequent milking operations [3],[6]. Women are particularly vulnerable to the musculoskeletal system disorders. This very common problem arises from the fact that workstations are designed, in most cases, based on the anthropometric measurements of men. Working in such conditions often causes discomfort, reduced productivity and higher energy expenditure. It has been found out in the studies conducted so far that some women working continuously for 8 hours feel pain in hands, wrists and the neck [7].

The aim of the study was to measure the

burden applied on musculoskeletal system of milkers while milking cows in a "herringbone" type milking parlour (herringbone system) and the rotary milking parlour (rotary system) using the Job Strain Index method. The milking process consists of the following consecutive steps: preparation of equipment for milking, washing the udder, pre-milking massage of the udder, taking a sample of milk, proper milking, post-milking, post-milking massage, and cleaning the milking equipment. The oblique arrangement of work stations in the "herringbone" milking parlour gives the milker better access to the udder. Milking operations are performed as per the pipeline system; preparation for milking the next cows and setting up the milking appliances. In the analyzed rotary milking parlour, the cows during milking are set on a rotating platform, side by side, facing the middle of the device. The operating staff for such a milking parlour consists of a group of several people working on the outside of the platform. Milkers have limited access to the cows' udders because the connection of the milking appliances is performed between the legs of the animals in an uncomfortable position [6]. The average number of milked cows in the tested "herringbone" parlours was 65 animals (10 farms). For the rotary type parlour the average herd size was 128 cows (3 farms).

MATERIALS AND METHODS

The applied JSI method is used to evaluate the total load on the musculoskeletal system of the upper limbs (hands, wrists, forearms and elbows). The burden may arise from the repetition of movements, external force and body position during work. The estimation of the totalised index in the JSI method will allow assessing the risk of symptoms in the musculoskeletal system for a specific work [6]. Several criteria and rules must be satisfied to properly determine the totalised JSI. For this reason some indirect indicators (IE, DE, EM, HWP, SW, DD) are determined, which accurately characterize the course of the operations performed by the worker under test. The general formula for the index calculation is as follows [5]:

JSI = IE x DE x EM x HWP x SW x DD
where:
IE- Intensity of Exertion
DE- Duration of Exertion
EM- Efforts per Minute
HWP- Hand/Wrist Posture
SW- Speed of Work
DD- Duration of Task per Day

The risk of disorders in the motoric system of a worker in the tested workstation is evaluated according to the scale set out in Table 1.

Table 1. Criteria for risk evaluation in JSI method

Index value	Risk of disorders
JSI<3	Low
3≤JSI<5	Average
5≤JSI<7	High
JSI>7	Very high

Source: The author's own analysis based on [7]

The intensity of exertion (IE) in the formula is determined by the percentage of the force which is generated by a working person against the maximum force values for the person (Table 2).

Table 2. Intensity, duration and frequency of efforts as per JSI method

Scale	IE - force; %MVC	Factor IE	DE[% duration exertion]	Factor DE	EM [number/ min]	Factor EM
1	<10	2	<10	0.5	<4	0.5
2	20-29	3	10-29	1	4-8	1
3	30-49	6	30-49	1.5	9-14	1.5
4	50-79	9	50-79	2	15-19	2
5	80<	13	80-100	3	20<	3

Source: The author's own analysis based on [3]

For the purpose of measuring IE the electromyography (EMG) was used, which measured the muscle's maximal voluntary contraction percentage (% MVC) - generated in the muscles of the milkers forearm.
The duration of exertion (DE) is calculated as the percentage ratio of the duration of all the

efforts against the total observation time for the tested person. In turn, the effort frequency should be understood as a number of efforts observed per unit of time, usually per one minute (EM) [2].

It is important to determine the hand and wrist position (HWP) in the JSI method. Angular values are relevant for the evaluation of the burden for the hand position against forearm. As in the previous cases they are qualified in a scale of five. Another element examined within the presented method is the speed of work (SW), which depends primarily on the conditions under which the work process is performed (Table 3).

Table 3. Hand position, speed of work, and duration of the operation in Job Strain Index method

Scale	Hand position description [HWP]	Factor HWP	SW characte-ristics	Factor SW	DD [hour]	Factor DD
1	Very good	1	Very slow	1	<1	0,25
2	Good	1	Slow	1	1-2	0,5
3	Correct	1,5	Average	1	2-4	0,75
4	Bad	2	Fast	1,5	4-8	1
5	Very bad	3	Very fast	2	8<	1,5

Source: The author's own analysis based on [2]

The last calculated factor is the duration of activity during the day (DD). The duration time is specified in hours, according to the values in Table 3.

The study involved a group of 20 farmers (8 women, 12 men). It was performed on private farms; each measurement was repeated 2 times. All tested persons were healthy. Each person had a relevant experience as they had been milking for at least four years. There were right-handed and left-handed persons in the studied population.

RESULTS AND DISCUSSIONS

The first factor taken into account to assess the burden is the intensity of effort measured as %MVC for farmers' forearms during subsequent milking operations. Figure 1 presents the average values (%MVC) for the muscles of the left and right forearm by gender.

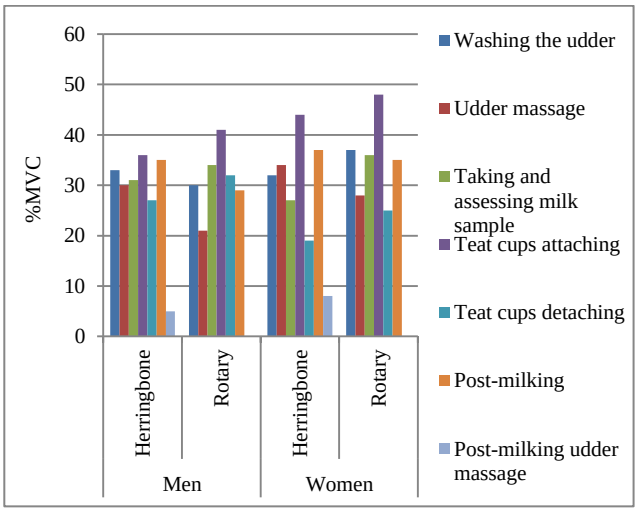

Fig.1. Average value of maximal voluntary contraction percentage (%MVC) for the muscles of forearm during each milking operation
Source: The author's own analysis

The %MVC distribution shows that maximum value of burden for muscles occurs during attaching teat cups, especially in case of women. At that operation the percentage of the maximum muscle tension exceeds 40% MVC.

No burden is recorded during teat cups detaching operation on the rotary milking parlour due to the automated finishing of milking. In the case of herringbone parlour the muscle tension for this operation does not exceed 10% of MVC.

According to the JSI method, the effort per minute rate observed during the milking operation was less than 4 (EM<4). Duration of exertion, defined as the percentage ratio of the duration of all the efforts against the total observation time for the milkers' work (DE ratio), amounted to 83.3% for milking in the herringbone parlour and 87.5% in the rotary milking parlour. An important element in the assessment of physical burden of farmers is the speed of work. The speed is assessed on the basis of the behaviour of the tested person, the duration of the subsequent operations and the factors related to the work environment. Figure 2 shows the example assessment of the speed of milkers' work. Axis x determines subsequent milking tasks by the number, while the y-axis determines the rate values (1-

5) describing the speed of work.

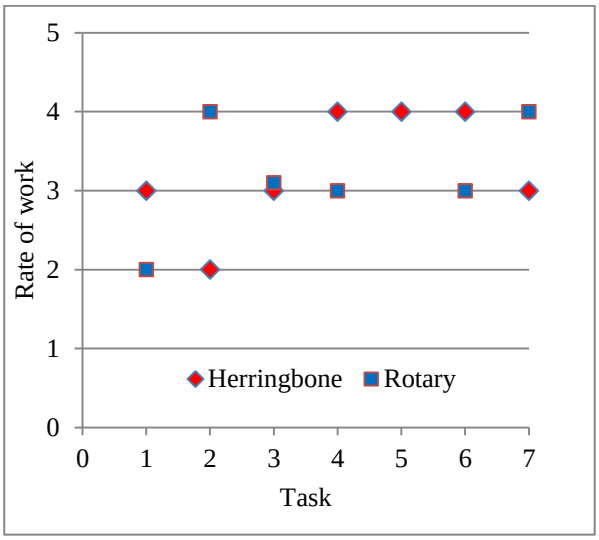

Fig.2. The observed rate of work of milkers while performing subsequent tasks SW (1-7); 1 - Very slow, 2 - Slow, 3 - Average, 4 - Fast, 5- Very fast. Tasks; 1- washing the udder, 2- udder massage, 3-taking and assessing milk sample, 4- teat cups attaching, 5- teat cups detaching, 6- post-milking, 7- post milking udder massage
Source: The author's own research

The data showed that the rate of work of milkers was higher for operations of attaching, detaching teat cups and post-milking in the herringbone parlour compared to the same operations measured in the rotary parlour.
It is important to consider the position of the body of the assessed person in the assessment of the work safety level.
For this purpose, bending angles were measured against optimal positions of selected parts of the motoric system.
Table 4 shows the values of bending angles (◦) against optimal positions for hands. The highest value of hand bending angle was measured during udder massage (18°), and the lowest during pre-milking. The highest values of bending while moving hands counter-clockwise were observed while washing udders (-35°), which was also accompanied by a high bending angle of fingers (35°).
The values refer to the right-handed individuals.
On the basis of the received indices (Table 5) respective multipliers were obtained, which allowed computing total load levels of 6.22 for the herringbone parlour and 4.62 for rotary milking parlour.

Table 4. Values of hand bending angles (◦) against optimal positions; standard bending angle value in brackets

Task/ Movement	Flexion	Extension	Radial deviation	Supination	Bent fingers
Washing the udder	-15 (3.5)	10 (2.1)	-14 (2.3)	-35 (7)	35 (5.5)
Udder massage	-18 (2.1)	5 (0.4)	-10 (3)	-25 (4.8)	20 (4)
Taking and assessing milk sample	-5 (0,2)	15 (3)	-20 (4)	-18 (3.9)	70 (10)
Teat cups attaching	-8 (1)	12 (2.1)	-15 (3.3)	-12 (4)	75 (12)
Teat cups detaching		-	-	-	-
Post-milking	-14 (2.4)	15 (2)	-20 (4)	-10 (3)	65 (8)
Post-milking udder massage	-15 (3)	8 (1)	-18 (4.2)	-22 (6)	24 (5.7)

Source: The author's own research

Table 5. Values of multipliers ascribed to each milking task as per Job Strain Index

Milking system	Herringbone					
Multiplier	IE	DE	EM	HWP	SW	DD
Washing the udder	3	1	0.5	1	1	0.5
Udder massage	3	1		1	1	0.25
Taking and assessing milk sample	6	1		1	1	0.5
Teat cups attaching	6	1		1.5	1.5	0.25
Teat cups detaching	6	0.5		1	1.5	0.25
Post-milking	6	0.5		1	1,5	0.25
Post-milking udder massage	3	0.5		1.5	1	0.25
Milking system	Rotary					
Washing the udder	3	1	0.5	1	1	0.5
Udder massage	3	1		1	1.5	0.5
Taking and assessing milk sample	6	1		1	1	0.5
Teat cups attaching	6	0.5		1	1	0.25
Teat cups detaching*	-	-		-	-	-
Post-milking	6	0.5		1	1	0.25
Post-milking udder massage	6	0.5		1	1.5	0.25

Source: The author's own research
* task performed automatically

This result translates to respectively high and average level of risk of developing disorders in the musculoskeletal system.
In the first case, breaks while milking should be introduced, especially when milking is performed by one milker (Table 6).

Table 6. Assessment of risk of developing disorders in the musculoskeletal system for the milking parlours under study as per Job Strain Index

Index value	Risk of developing symptoms	Total score - Herringbone parlour	Total score – Rotary parlour
JSI<3	Low		
3<JSI<5	Average		4.69
5<JSI<7	High	5.72	
JSI>7	Very high		

Source: The author's own research

Similar assessment by the JSI method was conducted for a number of other professions. The analysis primarily focused on forearms, wrists and hands of individuals under test. In the case of the waiter profession for example, it was found that the highest burden generating activities were those that required working in an upright position with arms exposed to external load greater than 5 kg where activity required at least 8 repetitions per minute.
Particular attention was paid to the extreme position of upper limbs, specifying the limit angles for their bending. In the case of the analyzed waiters' profession the overall JSI index value exceeded 20.
This result was much higher than that for the milkers. The difference might result from work organisation in both professions. In the case of waiters their activities were carried out for a period of 8-hour shift, while milking was usually divided into two four-hour cycles.
It is therefore necessary to minimize the burden for the motoric system so as to avoid overloading which leads to discomfort and often to irreversible problems.

CONCLUSIONS

The JSI method was applied to thoroughly analyse the burdens to the motoric system of milkers who performed milking in herringbone type parlour and rotary milking parlour.
The research showed that the milking work in the herringbone parlour generates a higher risk of problems to the musculoskeletal system of the milkers.
The risk ensues from a high frequency of repetitions of attaching the milking equipment and above all from the weight of the equipment.
The high value of the totalised index also results from the variable body position of the milker necessitated by the construction of this type of the milking parlour. In this case the milker covers longer distances than during milking in the rotary parlour.
It is therefore essential to change the milking work organization by introducing shifts or breaks.
Otherwise individuals working as milkers will suffer from discomfort and pains in the motoric system.

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