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USE OF SELECTED METHODS OF MEASUREMENT IN THE ASSESSMENT OF MILKERS' WORKLOAD IN THE TRADITIONAL MILKING

Summary

The activities connected with the milker's work are directly related to maintaining a special body posture due to the tension of specific muscles. Staying in one required position for a long time and work monotony in case have a negative effect on the person's musculoskeletal system. Therefore a study was conducted to evaluate the level of muscle tension and perceptible load while performing individual steps of hand-milking procedure. A detailed timing of the milker's work was also recorded. The workload was assessed according to the OWAS method and muscle tension was assessed according to the EMG method. On the basis of collected data it was assumed that the highest muscle tension for the evaluated group of 10 milkers was achieved with the forearm muscles. It is strictly connected with hands being raised forward and repeating the same movements. Based on the OWAS method it was observed that the milker's overall workload level can be described as medium. Farmers conducting milking should have adequate work breaks and should reduce workload on the musculoskeletal system whenever possible.
***Key words**: ergonomics, milker, EMG method, OWAS method, muscular load*

ZASTOSOWANIE WYBRANYCH METOD POMIAROWYCH W OCENIE OBCIĄŻENIA PRACĄ DOJARZY W DOJU TRADYCYJNYM

Streszczenie

Czynności związane z pracą dojarzy wiążą się bezpośrednio z utrzymaniem pożądanej pozycji ciała dzięki napięciu odpowiednich mięśni. Długotrwałe utrzymywanie wymuszonej pozycji ciała oraz monotonia pracy dojarza negatywnie wpływają na jego układ mięśniowo-szkieletowy. W związku z tym przeprowadzono badania, których celem była ocena poziomu napięcia mięśniowego i odczuwalnego obciążenia podczas wykonywania poszczególnych czynności składowych dla doju ręcznego. Wykonano także chronometraż czynności pracy dojarza. Ocenę obciążenia pracą dojarzy wykonano metodą OWAS, zaś napięcia mięśniowego metodą EMG. Na podstawie uzyskanych wyników stwierdzono, że najwyższe napięcie mięśniowe dla badanej, 10-osobowej grupy dojarzy, uzyskano dla mięśni przedramienia. Związane jest to ściśle z wyciągniętymi ku przodowi rękoma, które wykonują powtarzalne ruchy. Na podstawie metody OWAS stwierdzono, że ogólny poziom obciążenia pracą dojarza określić można jako średni. Rolnicy wykonując dój powinni dokonywać odpowiednich przerw w pracy oraz redukować, na ile to możliwe, obciążenie układu mięśniowo-szkieletowego.
***Słowa kluczowe:** ergonomia, dojarz, metoda EMG, metoda OWAS, obciążenie mięśniowe*

1. Introduction

Modern technologies connected with raw milk collection are mainly based on mechanical milking. Vacuum bucket milking and milking pipelines used so far are being replaced by modern tandem parlour milking systems, where obtaining milk becomes much more efficient. The replacement takes place not only in highly specialized dairy farms but also on much smaller farms whose technological progress in milk production is very high. The research conducted by G. Fiederowicz shows that 30% of farms use vacuum bucket milking, approx. 40% use milking pipelines and 25% use milking parlors. Hand-milking constitutes about 5% of all the applied methods of milking. Nevertheless, as research results show, even on dairy farms applying advanced technologies, hand-milking is occasionally conducted [4]. This milking form is applied when inflammation of the cow's udder has been diagnosed and sometimes in the last stage of dry period after calving.

Hand-milking persons are at high risk of developing diseases of the musculoskeletal system. It is a very common problem in the agricultural work environment due to inadequately designed work posts, bad posture assumed by the milker during milking activities and external factors affecting the milker [3]. Disorders of the musculoskeletal system are also caused by monotonous work [1].

2. The aim and scope of the paper

The aim of the research was the evaluation of the load imposed on the musculoskeletal system using the OWAS method and the analysis of muscle tension using the EMG method in the process of hand-milking in dairy cows. The analysis was conducted on 10 milkers during the morning and evening milking on their own farms in Radom County.

Apart from specifying the milkers' muscle tension while performing individual activities at milking, the research objective was also to create a chronometer for all milker's activities and to define assumed body postures and workloads for respective parts of muscles.

3. Research methodology

Static muscle tension in farmers was measured with an electromyogram - a device used to measure electric potential produced by the NORAXON DTS Company, which has the international certificates: SENIAM and ISEK. The device enables to measure 4 human muscles simultaneously

with surface electrodes. The average value of static muscle potential ranges from -40 mV to +40 mV while the muscles are involved in light labour. The measurement error is 2 mV. The EMG method enables to record and thoroughly analyse the EMG signal and at the same time transfer the signal to the MyoResearch XP software in order to statistically compute raw data. Surface electromyography, apart from the analysis of spatiotemporal parameters and kinematic values, is used to determine the correct posture of the milker at work [4]. The measured muscle tension is directly proportional to the force generated by the muscle and to the load resulted from the work performed [3].

In order to specify the time devoted to particular activities connected with milking, a digital camera connected in real-time with the EMG device was used. The recorded image was analyzed and the chronometer of the milkers' work time was created. External conditions in the facilities in which the research was conducted, such as the temperature and humidity, were similar for all the milkers involved in the analysis.

The photographs of milking activities were also used in the OWAS method, which precisely determines the milker's body posture. The examined sample consisted of farmers who are individual farm owners. The research was conducted during the morning and evening milking repeating ten times the whole milking process for each milker. The analyzed group comprised 7 women and 3 men. The main idea of the OWAS method involves different combinations of positions of the back, hands and shoulders, and adjusting proper external workload imposed on the analyzed [2, 6].

This is the basis for determining the code of the milker's body postures, which is then qualified to one of the four categories of workload assessment. The first category specifies the optimal workload because the assumed posture remains natural. The second category refers to the load on the musculoskeletal system, which may impose a negative effect on the milker's posture. The third category corresponds to a large load on the musculoskeletal system; therefore such a work post demands an immediate change [5].

The last category describes the level of the muscular system load as very high and negative for health. Changes at such posts must be made very quickly. Table 1 shows point numbers given to the analyzed body postures and the external load.

4. Research results

The height values of the examined milkers ranged from 157 to 181 cm; an average age was 35.6 years. The measurements of the arm and forearm of the examined individuals were also taken. All the anthropometric measurements are given in Table 2.

Table 2. Anthropometric characteristics of the observed milkers
Tab. 2. Antropometryczne cechy badanych dojarzy

Feature	Medium	Standard deviation	Range
Age [years]	35.6	2.8	29-41
Height [cm]	169	10.5	157-181
Weight [kg]	67	11.8	58-79
Length of the arm [cm]	27.8	2.6	25-29
Length of the forearm [cm]	24.7	2.2	21-27

Source: The author's measurements / Źródło: opracowanie własne

Traditional milking process involves several consecutive activities: preparing the tank for milk, udder washing, pre-milking massage, taking a milk sample, milking proper, post-milking and finally washing the used equipment after milking.

Table 1. Combinations of the position of the back, shoulders, legs and external workload according to the OWAS method [6]
Tab. 1. Kombinacje położenia pleców, ramion, nóg oraz obciążenia zewnętrznego wg metody OWAS [6]

Back	Shoulders	1			2			3			4			5			6			7			Legs
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Workload
1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	3	1	1	1	1	1	1	1	1	1	2	2	3	2	2	3	1	1	1	1	1	2	
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	2	3	3	
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4	
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4	
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1	
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1	
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1	
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4	
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4	

Among the activities, milking proper and washing the bucket after milking are the most time-consuming activities for the milkers, taking respectively 63.55% and 17.76% out of the total milking time (Table 3). According to the data, preparing the tank for milk and post-milking udder massage lasted the shortest - 10 seconds each, which constituted 1.87 % of the total milking time.

While examining each of the activities, the average electric potentials of involved muscles were specified for the assessed group. Figure 1 shows average EMG values for the forearm muscles of the milker's left and right hand respectively. Milking was performed with both hands and all the observed individuals were right-handed.

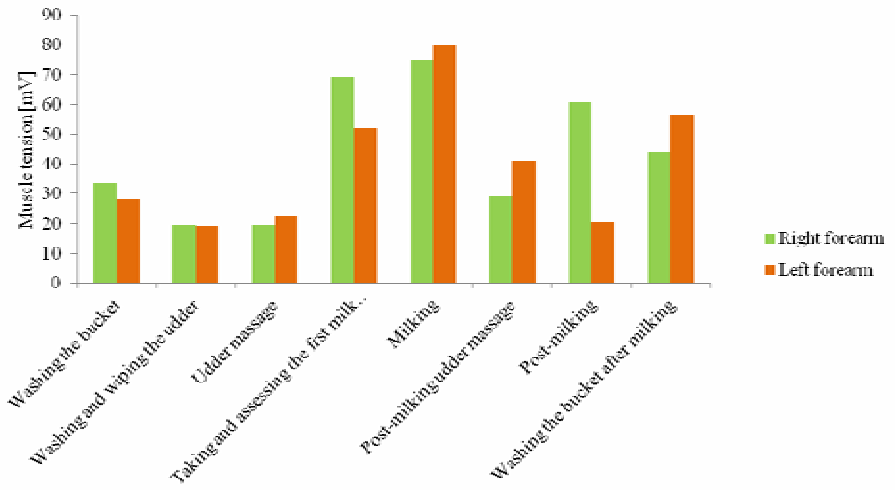
The highest average tension was recorded for the longest activity - milking the cows - about 80 mV for the left forearm muscles. Similarly high values were recorded during post- milking and initial milking. The lowest potentials of 20 mV were recorded during massage as well as washing and wiping the cow's udders.

Figure 2 shows the electric potentials of muscles of the left and right forearms for a (male) milker during the first 30 seconds of milking. The record clearly shows that the potentials are similar to the sinusoid curve. The peak points of the lines reflect the moments at which the milker obtained milk from the teat.

Table 3. Average time needed to perform individual activities in traditional milking
Tab. 3. Rozkład przeciętnego czasu trwania poszczególnych czynności w doju tradycyjnym

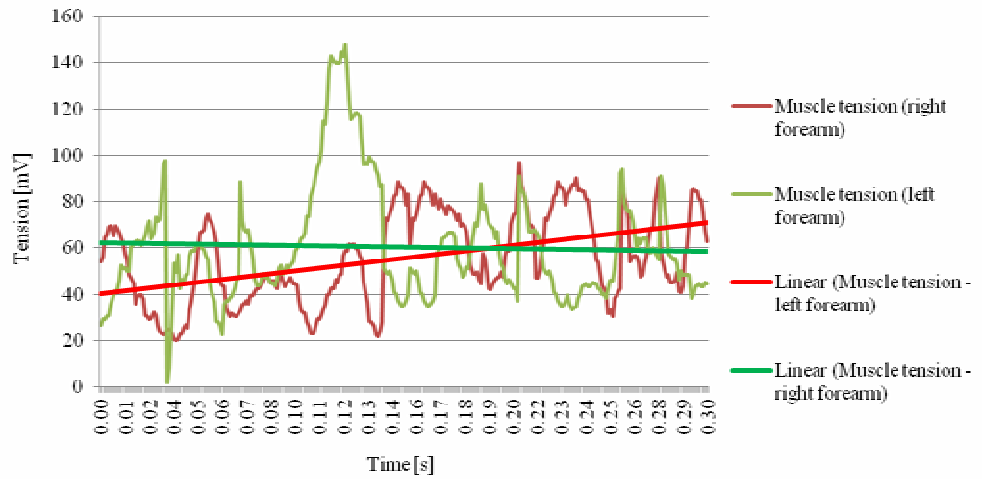
Activity	Time [s]	Time percentage [%]
Preparing the bucket for milking	10	1.87
Washing and wiping the udder	18	3.36
(Pre-milking) Udder massage	15	2.80
Taking and assessing the first milk sample	25	4.67
Milking	340	63.55
Post-milking udder massage	10	1.87
Additional milking	22	4.11
Washing the bucket after milking	95	17.76
Total	535	100

Source: The author's measurements / Źródło: opracowanie własne



Source: The author's measurements / Źródło: opracowanie własne

Fig. 1. An average muscle tension value of the forearm muscles for each activity involved in milker's work
Rys. 1. Średnia wartość napięcia mięśniowego dla mięśni przedramienia dla każdej z analizowanych czynności podczas pracy dojarza



Source: The author's measurements / Źródło: opracowanie własne

Fig. 2. Electric potentials of the milker's forearm muscles at milking
Rys. 2. Przebieg potencjałów elektrycznych mięśni przedramienia u dojarza podczas doju

The distribution of electric potential in muscles, which is similar to Figure 1, was specified for the load of the neck muscles. The highest value was recorded immediately after milking because, as observed in previous studies, this activity is the longest in the whole milking process. The lowest value recorded - 18.6 mV - refers to washing the bucket after milking in the upright position of the body (Figure 3).

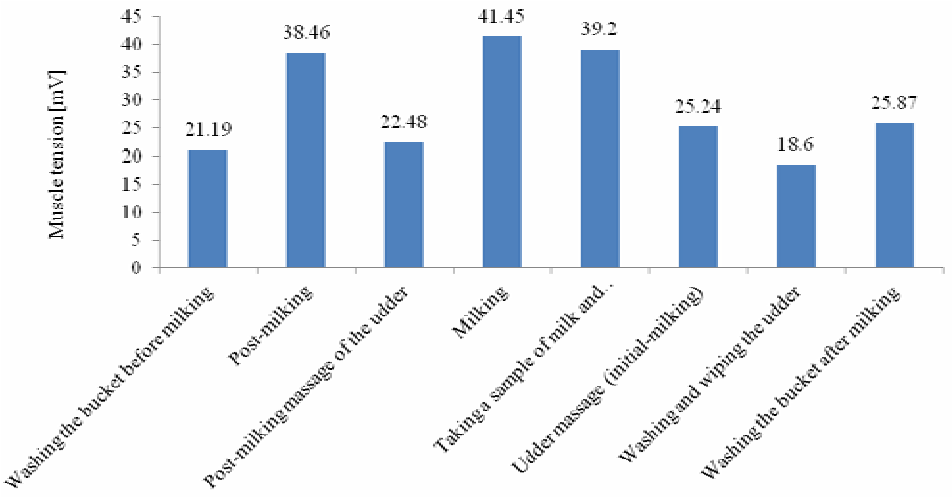
Figure 4 shows average values of electric potential for the back muscles. In this case the highest electric potential of muscles is generated during the milking proper and the additional milking of a cow and equals respectively 70 and 78 mV for women and 67 and 62 mV for men.

The potentials for women and men differ considerably. In such activities as udder massage, washing and wiping the udder as well as washing the bucket after milking, a higher electric potential was observed in the men's muscles. It was on average by 7 mV higher than the potential recorded in women. On the other hand, in the milking proper, additional milking and post-milking massage a higher activity was observed in the women's muscles.

5. OWAS method

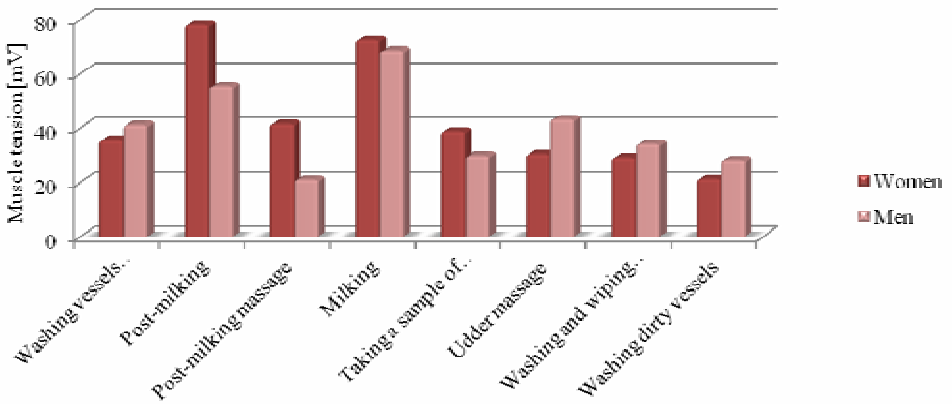
The second method used for the evaluation of static workload at the milker's post is a Finnish method - OWAS. Following it, Table 4 encodes the body positions assumed by the milker. The arm position is predominantly described as code 1, which means that both hands are situated inferior to the shoulder joint. The milker's legs are most frequently situated in a sitting position and the body trunk leans forwards, which is code 2 for the body trunk.

Each of the performed activities was assigned a code of the external force affecting the milker's posture. In each of the analyzed postures the load was lower than 10 kg. Based on such a coding of assumed postures, two characteristic posture formats can be distinguished: "2112" and "1122". The first posture lasted 80.4% of milking time. It was connected with such a posture of the milker in which the milker's back was leaning forward, the hands were inferior to the shoulder joints and the legs were in a sitting position at the external load below 10 kg. For the rest of the time, however, the milker's back was straight, both hands were below the shoulder joints and the legs were in a standing position at the external load not higher than 10 kg. The milker's postures described above show an average work load.



Source: The author's measurements / Źródło: opracowanie własne

Fig. 3. Average muscle tension of the neck muscles in the analyzed group of milkers
Rys. 3. Średnie napięcie mięśniowe dla mięśni szyi u badanej grupy dojarzy



Source: The author's measurements / Źródło: opracowanie własne

Fig. 4. Average muscle tension for the milker's back muscles
Rys. 4. *Średnie napięcie mięśniowe dla mięśni grzbietu dojarzy*

Table 4. Coded postures of the milker's body according to OWAS method
Tab. 4. Zakodowane pozycje ciała dojarza według metody OWAS

Activity	Time [s]	Body trunk Code	Arm Code	Leg Code	Force Code	Grade Category
Preparation of a vessels	10	1	1	2	2	2
Udder washing	18	2	1	1	2	2
Udder massage	15	2	1	1	2	2
Taking and assessing the first sample of milk	25	2	1	1	2	2
Milking	340	2	1	1	2	2
Post-milking massage	10	2	1	1	2	2
Post-milking	22	2	1	1	2	2
Washing dirty vessels	95	1	1	2	2	2

Source: The author's measurements / Źródło: opracowanie własne

6. Summary

Based on the research it was noted that the longest activity in the whole milking cycle was milking itself. The least time was devoted by milkers to preparation for milking and post-milking udder massage. The highest value of muscle tension in hand-milking was observed in forearm muscles. It is primarily connected with the monotony of the milker's work and the uncomfortable posture assumed by the milker. The lowest electric potentials were recorded for the neck muscles.

According to the OWAS method, most activities performed by the milker are connected with the uncomfortable body posture. Workload for all the activities connected with milking was defined as the medium level. The milkers at milking assumed a sitting position, their hands were inferior to the shoulder joint, the body posture was slightly leaning and the external load was lower than 10 kg.

The milker's work is potentially exposed to the risk of some musculoskeletal disorders. Therefore it is essential for the milker to have breaks at work in order to lower the level of muscle tension and reduce the load of the musculoskeletal system.

7. References

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