Changes in work heaviness and intensity at farms with robotics

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Abstract. The article discusses the problems of changing the essence of work of agricultural workers in the context of introduction of digital technologies. The research aims to study the changes in heaviness and intensity of work of agricultural workers as a result of introduction of digital technologies. As research methods, the workplace of a robotic milking operator was assessed in comparison with a machine milking operator. And 7 indicators belong to class 1 and 6 indicators to the second class of the working conditions, therefore, a general assessment of work heaviness corresponds to the class "Acceptable" (class 2). The assessment of work intensity revealed 7 indicators that belong to class 3.1 (stressful work of the first degree) and 3 indicators to class 3.2 (stressful work of the second degree). This allows making a conclusion that a general assessment of work intensity of a robotic milking operator corresponds to the class of stressful work of second degree. The use of robotic milking can be recommended to reduce the loads for livestock workers. At the same time, attention should be paid to reducing the work intensity of robotic milking operators.

1. Introduction

Work activity is an integral part of the social and daily life of people. A large proportion of the population spends most of their time at the workplace, so a job is something greater than just an income. The organization and conditions of work have a positive or negative impact on the quality of life, depending on the heaviness and intensity of work. For these reasons, the heaviness and intensity of work and their improvement are an important scientific problem that is studied in research of many scientists around the world [1, 2]. These aspects of work activity are of particular relevance for such a conservative industry as agriculture [3].

Thus, according to a study by Iranian scientists, the work activity in agriculture is a top priority for improving safety, health and working conditions. And the most problematic elements in work include ergonomic indicators and an index, management of hazardous chemicals and organization of a work schedule [4].

Some researchers analyzed modern working conditions in main sectors of agricultural production and identified a serious risk and harmfulness of the main conditions and appreciated the occupational health risk for workers in the industry as high [5]. According to the researchers from France [6], the working conditions can be assessed as acceptable and improper for the life of workers; activities, the amount of free time, reduction of harmful and dangerous conditions are of the greatest importance. While there are notable differences in requirements for farmers (especially in terms of the number of vacation days), most of these elements are relatively easy to assess. However, the working conditions
also affect workers' mental health and self-realization: identity development, co-residence (with people and/or animals), and development of sensitivity and skills. Finally, the working conditions must meet the requirements in production and time and guarantee subjective development [7].

2. Materials and Methods

The International Labor Organization (ILO) and the European Union (EU) have a long-standing commitment to improve the working conditions and quality of the working environment. The ILO was founded in 1919 with the aim of improving the working conditions that consider injustice and deprivation of significant numbers of people. This mission was verified in the ILO Declaration of 1944 in Philadelphia, which records a fundamental organizational principle, “Work is not a commodity” and refers to the need to act in such a way that workers “can get satisfaction with all their skills and achievements and make the greatest contribution to general well-being”.

The main hypothesis of the study is that the heaviness and intensity of work of agricultural workers is significantly reduced with the introduction of digital technologies in agricultural production.

The research aims to study the changes in heaviness and intensity of work of agricultural workers after the introduction of digital technologies.

The research objectives are:
- to assess the parameters of dynamic physical load on operators of robotic and machine milking;
- to assess the amount of stereotypical working movements of operators of robotic and machine milking;
- to assess intellectual, sensory and emotional stress of operators of robotic and machine milking;
- to give a comparative assessment of monotony and mode of operation of operators of robotic and machine milking;
- to classify working conditions and carry out a comparative assessment of heaviness and intensity of work of operators of robotic and machine milking.

To achieve the goal and objectives of the study, there was an assessment of the workplace of a robotic milking operator (ORM) in comparison with a machine milking operator (OMM). Methods of inclusive observation of the functions performed by workers at two farms were used - with milking by robots and a linear milking system. As the majority of milking machine operators are women, assessing the heaviness and intensity of work was carried out through observation of the operators of robotic milking of the same gender. The study covered all farms in the Sverdlovsk region. In addition, the analysis of description of formalized functions, primarily the job descriptions of a robotic milking operator, was carried out. To measure the time use, the timing of the working time of a robotic milking operator was used.

The indicators of work intensity were assessed in accordance with the hygienic criteria for assessing the working conditions in terms of harm and risks in the working environment, the heaviness and intensity of the working process [8]. In this case, a certain class of working conditions can be adopted to a workplace. So, if the working conditions are characterized with low physical activity and allow maintaining high performance of a person during the working day, this corresponds to the optimal working conditions (class 1). If the physical activity is higher than in the previous case, but it allows restoring a person's working capacity during a rest period, this corresponds to the second class of working conditions with acceptable physical activity (class 2). The high physical activity that requires restoring of the functional state of a body for more than until the next working day (shift) corresponds to harmful working conditions of the first degree (class 3, harmful working conditions of the 1 degree). When a person is in harmful and dangerous technical working conditions, which cause stable changes in the body and lead to occupational diseases of mild heaviness (with maintenance of working capacity for 15 years), it corresponds to the 3rd class of hazardous working conditions of the 2nd degree. There are harmful working conditions of the third, fourth degrees, as well as hazardous working conditions (class 4), but they will not be studied in our research.
3. Results and Discussion
One of the most important characteristics that determines the heaviness and intensity of working conditions is the amount of physical dynamic loads. To determine them at farms of the Sverdlovsk region, the indicators of a weight of transported goods were calculated taking into account the distance of their transportation. A class of the working conditions was given (with consideration of the regional and local load) depending on the amount of mechanical work per shift (table 1).

Table 1. The assessment of working conditions of a robotic milking operator in terms of heaviness of a working process.

| Indicator                                                                 | Actual value | Class of the working conditions |
|--------------------------------------------------------------------------|--------------|---------------------------------|
|                                                                          | OMM ORM OMM ORM |
| 1. Physical dynamic load (a unit of external mechanical work per shift, kg/m) |              |                                 |
| 1.1. With regional load (primarily with the muscles of arms and a shoulder girdle) with moving a weight up to 1 m | 4500 2800 | 3.2 2 |
| 1.2. With general load (with the muscles of arms, carcass, legs)          |              |                                 |
| 1.2.1. With moving a weight from 1 up to 5 m                              | 25500 18000 | 3.2 2 |
| 1.2.2. With moving a weight over 5 m                                      | 45000 24000 | 3.2 2 |
| 2. Weight of a lifted and moved object by hands (kg)                      |              |                                 |
| 2.1. Lifting and moving of a weight (one-time) with changing with other work (up to twice an hour): | 15 8 | 3.2 2 |
| 2.2. Lifting and moving (one-time) of a weight constantly during a shift | 12 5 | 3.2 2 |
| 2.3. Total weight moved during every hour of a shift:                     |              |                                 |
| 2.3.1. From a working surface                                             | 550 80 | 3.1 1 |
| 2.3.2. From the floor                                                     | 300 35 | 3.1 1 |
| 3. Stereotypical working movements (quantity per shift)                   |              |                                 |
| 3.1. With local load (with the muscles of hands and fingers)             | 65000 12500 | 3.1 1 |
| 3.2. With regional load (primarily with the muscles of arms and a shoulder girdle) | 32000 8000 | 3.2 1 |
| 4. Statistical load - a value of a statistical load per shift when holding the weight, applying forces, kgf / s) |              |                                 |
| 4.1. With one hand                                                        | 38000 9000 | 3.1 1 |
| 4.2. With two hands                                                       | 72000 18000 | 3.1 1 |
| 4.3. With the muscles of a carcass and legs                               | 92000 24000 | 3.1 1 |
5. The working posture

|                     | Periodically more than 50% of the shift time | Free comfortable posture, Standing up to 40% of the working time | 3.2 | 1 |
|---------------------|---------------------------------------------|---------------------------------------------------------------|-----|---|
|                    |                                             |                                                               |     |   |

6. Body tilt (more than 30°)

| 6.1. In a horizontal direction | 280 | 89 | 3.1 | 2 |
|--------------------------------|-----|----|-----|---|
| 6.2. In a vertical direction   |     |    |     |   |

7. Movements in space due to the technological process, km

| 7.1. In a horizontal direction | 11  | 12 | 3.1 | 3.2 |
|--------------------------------|-----|----|-----|-----|
| 7.2. In a vertical direction   |     |    |     |     |

As the data in Table 1 shows, with a regional load, a weight of an object moved by a robotic milking operator is 2800 kg, and by a machine milking operator is 4500 kg. This indicator classifies the working conditions of a robotic milking operator as an acceptable class (an average physical activity), and a machine milking operator gets the 3rd class of the 2nd degree. The mass of a weight moved at various distances was measured on scales and summed up per shift. And a value of an object moved over 5 meters by a robotic milking operator is 18 000 kg, which corresponds to a permissible class of working conditions (an average physical load), and by a machine milking operator is 45 000 kg, which corresponds to the third class (the second degree of harm) of working conditions.

Lifting and moving (one-time) of a weight with changing with other work was calculated by weighing on a scale. A maximum mass of an object was considered. It was 15 kg for a machine milking operator, which corresponds to the highest class of working conditions (a harmful (hard) work) and 8 kg for a robotic milking operator - an acceptable class of working conditions (an average physical activity). The total mass of moved weights during each hour of a shift was calculated from the floor and working surface. At the same time, the mass of objects moved by a machine milking operator was 550 and 300 kg, respectively, from the working surface and floor, which is proportional to the third class of work (the first degree of harm). The mass of objects moved by a robotic milking operator was 80 and 35 kg, respectively, which makes it possible to identified it as the first (a light physical activity) class of working conditions.

The number of stereotypical movements during the working day is important for assessing the heaviness of work. These are repetitive movements, in which the same muscle groups are involved. As observations reveal, the number of these movements performed by a machine milking operator was 65 000 with a local load involving the muscles of hands and fingers and 32 000 with predominant involvement of the muscles of arms and shoulder girdle. These indicators correspond to the harmful working conditions of the third class (the first degree of harm). The number of stereotypical movements of a robotic milking operator was 12 500 with the muscles of hands and fingers and 8 000 with the muscles of arms and shoulder girdle, which corresponds to a light physical activity (class 1).

The working posture of the machine milking and robotic milking operators was determined visually. The characteristic working postures were identified in a sitting, standing, squatting position, etc. The time spent in the working position was determined by time-based observations during a shift, after that it was calculated in relative values (in percent). According to the observation data, a machine milking operator is in an uncomfortable position for more than 50% of the shift time, while being in a standing position is for up to 80% of the working time, which corresponds to harmful working conditions (class 3) of the 2nd degree. The working posture of a robotic milking operator is generally comfortable and free, and being in a standing posture is only up to 40% of the working time. This corresponds to an optimal physical activity (1 class). It should be noted that both categories of workers travel a long distance during the day, this parameter makes it possible to classify their working conditions as class 3.

A significant characteristic of work is the intensity of a working process, which reflects an effect
on the central nervous system and is determined by the duration of a psychoemotional stress and the intensity of an intellectual load (Table 2).

**Table 2.** The assessment of working conditions of a robotic milking operator by intensity of a working process.

| Indicator | Actual value | Class of the working conditions |
|-----------|--------------|----------------------------------|
| **1. Intellectual loads:** | | |
| 1.1. Work content | Solving simple tasks | 2 |
| | Solving complex tasks with a choice according to well-known algorithms | 3.1 |
| 1.2. Perception of signals (information) and assessing | Perception of signals with further correction of actions and operations | 2 |
| | Comprehensive assessment of all production activities | 3.2 |
| 1.3. Distribution of functions according to a degree of a task complexity | Processing, completion of a task and its verification | 2 |
| | Processing, checking and monitoring the completion of a task | 3.1 |
| 1.4. Nature of work | Working under time pressure | 3.1 |
| | Working under time pressure | 3.1 |
| **2. Sensory loads** | | |
| 2.1. Duration of focused observation (in % of shift time) | Up to 25 | 1 |
| | 26-50 | 2 |
| 2.2. Density of signals (light, sound) and messages on average per 1 hour of operation | Up to 70 | 1 |
| | 76-175 | 2 |
| 2.3. The number of production objects for simultaneous observation | 6-10 | 2 |
| | 11-25 | 3.1 |
| 2.4. A size of an object (the distance from the worker’s eyes to an object is not more than 0.5 m) in mm with duration of concentrated observation (% of shift time) | Over 5 mm 100% | 1 |
| | Over 5 mm 100% | 1 |
| 2.5. Working with optical devices (microscopes, etc.) with duration of concentrated observation (% of shift time) | Up to 25 | 1 |
| | Up to 25 | 1 |
| 2.6. Monitoring the screens of video terminals (hours per shift): with an alphanumeric type of information display: | 0 | 1 |
| | 3 | 2 |
| | With a graphical type of information display: | 0 | 1 |
| | 2 | 1 |
2.7. The load on the auditory analyzer (with the production need for perception of speech or differentiated signals)

Word and signal intelligibility from 70% to 50%. There are interferences, with the background a speech is heard at a distance up to 2 m.

2.8. The load on the voice apparatus (the total number of hours spoken per week)

|          | Up to 16 | Up to 20 |
|----------|----------|----------|
|          |          | 1        |

3. Emotional loads

3.1. The degree of responsibility for the result of her own activities. The significance of a fault

|          | Is responsible | Is responsible |
|----------|----------------|---------------|
|          |                | 3.1           |

3.2. The degree of risk to her own life

|          | Possible | Possible |
|----------|----------|----------|
|          |          | 3.2      |

3.3. Degree of responsibility for the safety of others

|          | Possible | Possible |
|----------|----------|----------|
|          |          | 3.2      |

3.4. The number of conflict situations caused by professional activity, per shift

|          | 4 | 2 |
|----------|---|---|
|          | 3.1 | 2 |

4. Monotonicity of loads

4.1. The number of elements (operations) required to make a simple task or multiple repetitive operations

|          | 4 | 10 |
|----------|---|----|
|          | 3.1 | 1 |

4.2. Duration (in seconds) of doing simple production tasks or repetitive operations

|          | 20 | 50 |
|----------|----|----|
|          | 3.1 | 2 |

4.3. Duration of active actions (in % to the shift duration). The rest of the time involves monitoring the progress of the production process

|          | 60 | 22 |
|----------|----|----|
|          | 1  | 1  |

4.4. Monotony of the production environment (time of passive observation of a progress of a technical process in % of the shift time).

|          | 40 | 50 |
|----------|----|----|
|          | 1  | 1  |

5. Working hours

5.1. Actual working hours

|          | 8-9 | 10-12 |
|----------|-----|-------|
|          | 2   | 3.1   |

5.2. Shift schedule

|          | Two-shift work (no night shift) | Two-shift work (no night shift) |
|----------|---------------------------------|---------------------------------|
|          | 2                              | 2                               |

5.3. Availability of regulated breaks and their duration

|          | Free time duration from 3 to 7% | Free time duration over 7% |
|----------|---------------------------------|----------------------------|
|          | 2                               | 1                           |

Intellectual loads in work are the difficulty of performed activities from simple tasks to work that requires a creative, heuristic approach. As one can see from the data in the table, a machine milking operator solves mostly simple tasks, and the activity of a robotic milking operator is aimed at solving...
complex tasks with a set of instructions. And the work of a machine milking operator involves perception of signals with further correction of actions and operations, and the activity of a robotic milking operator requires a comprehensive assessment of all production activities. At the same time, both categories of workers perform production tasks under time pressure conditions.

Sensory loads are associated with involvement of a human signaling system in the production process, including hearing, vision and speech. The activities of both analyzed groups of workers are characterized with insignificant time of concentrated observation (up to 25% and 50% of the working time), which corresponds to the optimal and acceptable working conditions by this parameter. At the same time, the density of signals also corresponds to the 1st and 2nd classes of work. It should be noted that a robotic milking operator has more simultaneous production objects than a milking machine operator. These objects include computer monitors on the desktop, which display various parameters of the milking robot and the milking process, various measuring equipment, compressors, etc. Both categories of workers have high loads on their acoustic apparatus because they work in high-noise environments. At the same time, the intelligibility of words and signals ranges from 70% to 50%, and a speech at such a background is audible at a distance up to 2m.

Emotional loads at the workplace are the ability of an employee to influence results of his work at various levels of work difficulty. The results of the study show that both categories of milking operators are responsible for a functional quality of basic work. If the instructions are not followed, this can result in large material and financial losses. In particular, if antibiotics are in milk, the whole batch of supplied products can be rejected. Farms with and without robotics have a large number of mechanisms with moving elements (conveyor belts, scrapers for removing manure, etc.), feed is dispensed with the use of tractors, and cattle are moving. This makes a degree of risk to one's own life quite high, and responsibility for the safety of others is possible. A number of conflict situations in the activities of a milking machine operator should be noted, which makes it possible to give class 3.1 by this indicator in terms of harmfulness of working conditions.

Monotony of loads is determined by a large number of repetitive operations of the same type. The work of a machine milking operator involves a small number of elements required for milking an animal, which makes it possible to give the 3 class of working conditions of the first degree. At the same time, a robotic milking operator uses a greater number of techniques to perform simple operations and his work is very diverse. At the same time, the time of active actions during the working hours is more than 20%, which makes their work optimal by this indicator. The working time of a robotic milking operator is up to 10-12 hours a day. In some cases, at night, an operator performs his functions remotely via the Internet, or is forced to return to the farm to troubleshoot robotics problems. This makes the work more stressful and allows giving the 3rd class of working conditions by this indicator, but this does not affect her performance greatly.

4. Conclusion
Thus, a general assessment of heaviness of a robotic milking operator's work revealed only one indicator associated with class 3.2 (stressful work of the second degree of heaviness). At the same time, 7 indicators belong to class 1 and 6 indicators to class 2 of the working conditions, therefore, the general assessment of heaviness of work corresponds to the class "Acceptable" (class 2) (table 3).

| Table 3. A general assessment of heaviness and intensity of work of a robotic milking operator |
|-----------------------------------------------|-----------------|-----------------|-----------------|-----------------|
| Indicators                                      | Class of working conditions |
|                                               | 1    | 2    | 3.1  | 3.2  |
| Number of indicators in each class              | 7    | 6    | 1    | -    |
| General assessment of work heaviness            | +    |      |      |      |
| Number of indicators in each class              | 8    | 5    | 7    | 3    |
| General assessment of work intensity            | +    |      |      |      |
The assessment of work intensity revealed 7 indicators that belong to class 3.1 (stressful work of the first degree) and 3 indicators to class 3.2 (stressful work of the second degree). This allows making a conclusion that a general assessment of work intensity of a robotic milking operator refers to stressful work of the second degree. The use of robotic milking can be recommended to reduce the load on workers at livestock farms, as a weight of moved objects and the number of stereotypical movements is lower than at traditional farms. At the same time, attention should be paid to reducing the work intensity of robotic milking operators, as a level of sensory loads and the number of objects of simultaneous observation are higher than at traditional farms.

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