Physical Ergonomics and Human Factors, Vol. 103, 2023, 125–134
https://doi.org/10.54941/ahfe1003043

Assessment of Risk Factors of Upper Limb Musculoskeletal Disorders in a Meat Processing Plant

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ABSTRACT

The aim of this study was to evaluate the risks associated with repetitive movements of the upper limbs in different meat processing tasks of a pig slaughterhouse, using the OCRA Checklist. The study was conducted in a Brazilian pig slaughterhouse with 1,000 workers, divided into two work shifts. To evaluate the risks associated with repetitive movements of the upper limbs, 10% of the workforce was assessed while carrying out their work tasks, using the checklist proposed by the OCRA method. Descriptive statistics and the Student t-test (SPSS 17.0) were applied to compare the risks between both sides of the workers' bodies ($p \leq 0.05$). There were 39 work activities analyzed from the productive sectors. The average of occupational repetitive actions performed by workers was 54.5 ± 20.8 per minute, representing 7 points on the OCRA scale (0 to 10 points). The average score of the OCRA Checklist was 18.8 ± 6.0 (medium risk). The scores for the right upper limb (18.6 - medium risk) differed statistically ($p = 0.016$) from the left upper limb (13.8 - medium risk). Five work tasks were considered high risk, 29 were classified as medium risk, one as low risk, one as very low risk and three as acceptable risk. Performing simulations in 32 of the 35 activities made it possible to reduce the UL-WMSD risk to very low levels, by only decreasing the work pace. In three of the activities, a very low risk level could not be achieved by only reducing the work pace, due to the high demand for strength required to perform these tasks. These results suggest that most pig processing tasks, classified as high (13%) and medium risk (74%), predispose workers to a greater probability of developing upper limb work-related musculoskeletal disorders (>21.5% probability for high risk and 10.8 to 21.5% for medium risk). Simulations of decreasing the work pace showed the effectiveness of this organizational measure to reduce the risk of UL-WMSDs.

Keywords: UI-WMSDs, Pig slaughterhouse, Risk assessment, Ergonomics, OCRA

INTRODUCTION

Brazil is the fourth leading producer and exporter of pork meat in the world (Brazilian Association of Animal Protein, 2022). Nevertheless, in recent years, improved work conditions in the meatpacking industry have not grown at the same rate as production growth (Sardá et al., 2009). The ergonomic-related risk factors that could lead to the development of upper limb work-related musculoskeletal disorders (UL-WMSDs) in meat processing include: repetitive work (Colombini and Occhipinti, 2004; dos Reis

et al., 2021; Nag et al.,‘2012; OSHA, 2013), artificially cold environments (Cummings, 2015; Tirloni et al., 2012, 2017), use of manual tools, and consequently, the applied force required for the tasks (Claudon and Marsot, 2006; Reis et al., 2016a; Viikari-Juntura and Silverstein, 1999), as well as the use of gloves (Buckle, 1997; OSHA, 2013).

In a study of 645 Danish slaughterhouse workers, a prevalence of pain in the shoulders, hands/wrists, and elbows of 60%, 52% and 40%, respectively, was found (Sundstrup et al., 2014). In addition, 38% of workers reported an inability to work due to pain in the upper limbs, emphasizing the functional consequences of pain in the shoulders, arms, and hands in daily work. Tirloni et al. (2018) also found that most workers at a pig slaughterhouse felt body discomfort in at least one region (83.3%) and the most affected body regions were shoulders (47.2%) and arms (25.0%). According to Sundstrup et al. (2016), chronic pain in the upper limbs is associated with reduced neuromuscular function of the shoulders and hands, along with impaired work capacity, inability to work, and general health.

Workers in pork slaughterhouses have high rates of acute injuries and chronic illnesses (Kyerematen-Amoah et al., 2014). Most reports of injuries from a pork processing plant (63%) occurred in cold workplaces, and the main source of injuries were tasks that required the use of hand tools (Cummings, 2015). Recent malfunctions of tool sharpening equipment have been associated with a higher rate of laceration injuries (Lander et al., 2012). Furthermore, intensive manual work, including high speed and high force, is a risk factor for musculoskeletal injuries in pig slaughterhouses (Frost et al., 1998). Moore and Garg (1994) presented additional epidemiological evidence that upper extremity musculotendinous disorders may be causally associated with work in pig slaughterhouses. Disorders included nonspecific hand/wrist pain, epicondylitis, carpal tunnel syndrome (CTS), trigger thumb, trigger finger, and De-Quervain’s tenosynovitis.

Exposure to risk factors due to multiple repetitive tasks performed regularly in the slaughterhouse environment has been observed and requires a systematic approach to quantify the proportion of these risks. With that in mind, the OCRA Checklist (Occupational Repetitive Actions) was developed to analyze the exposure of workers to risk factors for the development of Upper Limb Work-Related Musculoskeletal Disorders (UL-WMSD) (frequency of technical actions, postures of the upper limbs, strength demand, stereotypical moves or lack of postural variation, recovery periods and others, defined as “complementary”) related to the tasks performed (Colombini and Occhipinti, 2006). This method was based on a consensus document from a technical committee on musculoskeletal injuries of the International Ergonomics Association (IEA) (Colombini and Occhipinti, 2006). While there are several studies assessing the risk of developing UL-WMSDs among poultry slaughterhouse workers (Mohammadi, 2012; Pinetti and Buczek, 2015; Reis et al., 2015a, 2015b, 2016b, 2017), few studies have evaluated pig slaughterhouse workers (Botti et al., 2015; dos Reis et al., 2018; Pellegrini et al., 2014). These studies were limited to analyzing a small number of tasks in pig slaughterhouses (Botti et al., 2015; Pellegrini et al., 2014) or just meat processing tasks (sausages and similar products) (dos Reis et al., 2018).

Thus, the aim of this study was to evaluate the risks associated with repetitive movements of the upper limbs in different meat processing tasks of a pig slaughterhouse, using the OCRA Checklist.

METHOD

The local Ethics Committee in Research with Human Beings, in accordance with the Helsinki Declaration, approved the procedures of this study.

The study was conducted in a pig slaughterhouse with 1,000 workers employed, divided into two work shifts. The OCRA Checklist (Colombini et al., 2016) was applied to assess the risk of 39 work tasks, which included mostly meat processing factory workers. Subjects were randomly selected to participate in the study. Videos of 10 task cycles performed by each worker were recorded, while carrying out their work tasks, and used for subsequent analysis.

For data presentation, descriptive statistics in terms of mean, standard deviation and percentage were utilized. In order to compare the risks between both sides of the workers' bodies, the Student t-test (SPSS 17.0) was used ($p \leq 0.05$).

RESULTS AND DISCUSSION

A total of 39 work tasks from the productive sectors of the pig slaughterhouse were analyzed.

Each work shift totaled 8 h 48 min, including a lunch break (60 min), six rest breaks (10min) and the time to change clothes/uniform (clock in and clock out). Therefore, the net repetitive work time was classified in the range between 421 and 480 min, which represents the multiplier factor "one" on the OCRA Checklist.

Given that the company adopts six rest breaks distributed throughout the work shift, for the OCRA Checklist's "recovery" factor, the multiplier 1.05 was assigned for all tasks examined. To achieve the ideal multiplier (1.0) associated with the "recovery" factor (5:1 ratio work time to recovery time), it would be necessary to allocate at least one more break. Insufficient rest breaks for the recovery of fatigue caused by repetitive work in the industry can lead to muscle injuries (Kilbom, 1994). In an experiment testing the inclusion of extra rest breaks in a meat-processing plant, Dababneh et al. (2001) established that taking hourly rest breaks does not compromise production and are beneficial to the workers' well-being.

In relation to the other risk factors considered by the OCRA method (applied force, frequency of technical actions, posture, and complementary factors), scores were assigned according to the characteristics of each task and the technique adopted by each worker.

The average of technical actions performed by workers was 54.5 ± 20.8 per minute (Table 1), representing seven points on the OCRA scale (0 to 10 points). In another Brazilian pig slaughterhouse, dos Reis et al. (2018) presented similar results, observing an average of 64.1 ± 14.3 actions per minute, which

Table 1. Results of the risk assessment from the OCRA checklist and simulations to decrease the risk by reducing the work pace.

Tasks	Current situation				Simulations for risk reduction			
	Units/ min	TA/ min	OCRA score	Risk level	Units/ min	TA/ min	OCRA score	Risk level
Open thorax	6.0	30.0	33.5	5	*	*	*	*
Remove vertebra	6.0	30.0	32.5	5	*	*	*	*
Cover boxes	12.0	48.0	30.0	5	*	*	*	*
Shaving	6.0	120.0	30.0	5	2.0	40.0	10.5	2
Distribute pieces on sealer	23.1	69.2	24.0	5	12.0	36.0	10.5	2
Open abdomen	6.0	48.0	22.5	4	3.8	30.0	10.5	2
Label products on sealer	24.0	72.0	22.0	4	12.0	36.0	11.0	2
Remove skin from head	6.0	84.0	22.0	4	2.9	40.0	10.5	2
Separate parts of the shoulder	2.0	64.0	21.5	4	1.1	34.9	10.5	2
Expose scalpel bone	2.0	90.0	21.5	4	0.8	35.1	10.5	2
Disarticulate neck	6.0	48.0	20.0	4	3.8	30.0	11.0	2
Fill saw to separate rib and shoulder	24.0	48.0	20.0	4	15.0	30.0	11.0	2
Clean ham using knife	0.8	66.4	20.0	4	0.4	35.6	11.0	2
Remove meat from head	1.4	99.1	19.5	4	0.6	40.2	10.5	2
Debone shoulder butt	2.2	77.8	19.5	4	1.0	35.0	10.5	2
Debone picnic shoulder	1.6	58.4	19.5	4	1.0	35.2	10.5	2
Remove femur bone	1.1	57.9	19.5	4	0.7	35.2	10.5	2
Trim boneless picnic shoulder	1.5	72.3	19.5	4	0.9	40.3	10.5	2
Fil skin removing machine	15.0	45.0	19.0	4	10.0	30.0	11.0	2
Remove belly rib	2.7	49.1	18.5	4	2.0	36.0	10.5	2
Trim jowl	1.8	69.1	18.5	4	1.1	40.0	10.5	2
Remove skin from ham	4.6	50.8	18.5	4	3.2	34.7	10.5	2
Remove tail bone	1.2	54.2	18.5	4	0.8	35.3	10.5	2
Trim picnic shoulder	1.8	56.5	18.0	4	1.1	34.9	11.0	2
Remove skin from chop	2.0	60.0	17.5	4	1.2	36.0	10.5	2
Remove skin from shoulder	4.6	46.2	17.5	4	3.5	35.3	10.5	2
Secondary chop packaging	1.5	38.5	17.0	4	1.2	30.0	11.0	2
Clean shoulder with knife	2.2	48.9	17.0	4	1.6	35.7	11.0	2
Remove penis	6.0	54.0	16.5	4	4.0	36.0	10.5	2
Remove butt ham	4.3	42.9	16.5	4	3.5	35.3	10.5	2
Remove testicles	6.0	48.0	15.5	4	4.3	34.3	10.5	2
Remove viscera	6.0	42.0	15.5	4	5.0	35.0	10.5	2
Trim boneless shoulder butt	2.3	50.8	15.5	4	1.6	35.7	10.5	2
Trim ham	1.5	46.2	15.5	4	1.3	40.0	10.5	2
Position carcasses on conveyor belt	4.3	34.3	12.5	3	3.8	30.0	10.5	2
Rehang pigs	5.0	35.0	9.0	2	5.0	35.0	9.0	2
Secondary shoulder packaging	2.6	26.1	7.0	1	2.6	26.1	7.0	1
Secondary ham packaging	2.6	26.1	7.0	1	2.6	26.1	7.0	1
Remove jowl	4.3	17.1	6.5	1	4.3	17.1	6.5	1
Average	5.5	54.5	18.8	4	3.2	34.0	10.3	2
Standard-deviation	6.1	20.8	6.0		3.3	4.7	1.1	

Risk level: 5-high; 4-medium; 3-low; 2-very low; 1-acceptable (Colombini et al., 2016); TA-technical actions; *The task needs to be restructured due to the high force requirement.

corresponds to nine points on the OCRA Checklist. In a pig head processing company, Pellegrini et al. (2014) reported that the ergonomic analysis of work showed an elevated risk for disorders of the upper limbs due to the high frequency of technical actions (between 15 and 82.5) combined with awkward postures, applied force, complement factors and the lack of the necessary recovery time.

As suggested by Kilbon (1994), workers should not exceed 25–33 actions per minute, considering that frequencies above these values interrupt the physiological recovery mechanisms from operating efficiently, increasing the incidence of tendon injury.

Slaughter and meat processing work tasks require high load intensities and cyclic repetitive muscle actions of the upper limbs. In addition to limited time for recovery and temporary episodes of inability to work, the prevalence of musculoskeletal pain in the hands, arms and shoulders is high among slaughterhouse workers (Sundstrup et al., 2014). Studies have shown that most poultry (Tirloni et al., 2012, 2017) and pork (Tirloni et al., 2018) slaughterhouse workers felt body discomfort, with the shoulder region being the most affected (Pinetti and Buczek, 2015; Reis et al., 2012; Tirloni et al., 2012, 2017, 2018).

The average score of the OCRA Checklist for all tasks analyzed in the company was 18.8 ± 6.0 points (Table 1), which is considered a medium risk. The scores for the right upper limb (18.6 - medium risk) differed statistically ($p = 0.016$) from the left upper limb (13.8 - medium risk). Similar results (average 22.2 ± 7.7 - medium risk) were found in another pig slaughterhouse (dos Reis et al., 2018). In addition, a medium risk was also observed in several other Italian (Colombini and Occhipinti, 2004) and Brazilian poultry slaughterhouses (Reis et al., 2015a, 2015b, 2016b). Occhipinti and Colombini (2007) reported an OCRA Index of 23.8 (high risk) in pig slaughterhouse workers, with 86 workers evaluated and 193 diagnosed cases of WMSDs (224.42%). However, only one task was assessed in the study (Occhipinti and Colombini, 2007), while the results represent an average of various tasks in the other studies.

Considering the five risk categories proposed by the OCRA method, five work tasks (13%) were deemed high risk, 29 (74%) were classified as medium risk, one (2.5%) as low risk, one (2.5%) as very low risk and three (8%) as acceptable risk (Table 1). Another study in a Brazilian pig slaughterhouse analyzed 22 work tasks, where most of them (16) presented medium risk (73%), and six, high risk (27%) (dos Reis et al., 2018). Among three work tasks analyzed by the OCRA method in an Italian pig slaughterhouse, Botti et al. (2015) found one task representing high risk and two of low risk.

A series of studies carried out in Brazilian slaughterhouses raised the hypothesis that there was a reduction in the number of high-risk tasks due to the implementation of the Standard Regulatory Norm 36 (NR-36) (Brasil, 2013). This standard establishes the minimum requirements for evaluation, control and monitoring risks in tasks performed at meat processing plants. Among the requirements of the NR-36 that directly influence the results of the OCRA Checklist, a minimum duration of the psychophysiological recovery periods is established (20 min, 45 min or 60 min) (Brasil, 2013). Considering the duration of the shifts (up to 6h, up to 7h20min or 8h48min, respectively) in the plant's production sectors, this requirement should be adopted. The recovery periods ought to last at least 10 minutes and at most 20 minutes, and not be allocated in the first hour of work, contiguous with the meal interval or at the end of the last hour of the workday. Adopting these measures means decreasing the time exposed to repetitive tasks and / or muscular overload,

thus reducing the score of the "recovery" variable on the OCRA Checklist. Therefore, the hypothesis is evidenced by the disparity between the results of pre (Reis et al., 2015a) and post NR-36 studies (dos Reis et al., 2018; Reis et al., 2015b, 2016b, 2017). Reis et al. (2015a) evaluated a Brazilian poultry slaughterhouse prior to implementation of the NR-36 and found greater exposure to repetitive activities (> 480 min), with a shorter duration of daily rest breaks (1 × 10 min).

Based on epidemiological data, the precursors of the OCRA method (Colombini et al., 2016) developed hypotheses of disease prevalence expected in a particular occupational setting. Therefore, possible percentages were defined for each level of UL-WMSD incidence on the Checklist. In the meat deboning task, Colombini et al. (2016) found a UL-WMSD incidence of 47.7% in workers from workstations classified with 28 points on the OCRA Checklist (high risk). Thus, it can be affirmed that the workers analyzed in the present study who performed tasks of medium risk have a 10.76 and 21.51% probability of developing UL-WMSDs, whereas in high-risk tasks the probability is > 21.51%.

Pig slaughterhouse workers are exposed to ergonomic risks related to the physical load and physical environment (Vergara and Pansera, 2012). Musculoskeletal problems caused by poorly organized work environments are of concern, as they lead to the development of occupational diseases with negative economic and social repercussions, both for companies and governments, and especially families (Vitta et al., 2008). Therefore, an ergonomically appropriated workplace is of fundamental importance for the companies, due to the loss of employees, and for the government, which should provide payment of welfare benefits for treatment and rehabilitation (Vitta et al., 2008). Pellegrini et al. (2014) recommend considering some organizational factors for the prevention of UL-WMSDs in pig slaughterhouse workers: alternate tasks with worker rotations for more tasks; adopt a rational distribution of rest breaks (preferably hourly); use knives that have the handle covered by adherent material and do not cause compression in the hands; sharpen knives several times a day; provide information and training for workers on the proper use of knives and education on sharpening knives at the first signs of fatigue.

Given that highly repetitive movements of the upper limbs are characteristic of pig slaughterhouses (dos Reis et al., 2018; Frost et al., 1998; Pellegrini et al., 2014; Stoy and Aspen, 1999), and previous studies suggest decreasing the work pace to prevent UL-WMSDs (dos Reis et al., 2018; Reis et al., 2015a, 2015b, 2016b, 2017; Tirloni et al., 2012), simulations of a reduced work pace to achieve very low risk levels utilizing the OCRA Checklist were performed (Table 1). Through simulations in 32 of the 35 activities that needed adjustments, it was possible to reduce the risk of UL-WMSDs to very low levels, by decreasing the work pace (-36.9%) (proportionally adjusting the exposure time to each risk factor). In three of the tasks, a very low risk level could not be achieved by only reducing the work pace, due to the high demand for strength required to perform these tasks. Dos Reis et al. (2018) also carried out simulations of a reduced work pace in pig slaughterhouse

tasks, aiming to lower the risk of UL-WMSDs. When the pace was reduced to -46.7 ± 14.8%, very low risk levels were achieved for most of the tasks analyzed (19/22), except for those activities requiring significant force exertion.

CONCLUSION

Based on the results of this study and the postulation of the literature, the following can be concluded:

- Most activities carried out by the workers were classified as medium risk;
- The risk of developing UL-WMSDs in the analyzed activities was higher for the right side of the body;
- Simulations of a reduced work pace showed the effectiveness of this organizational measure to lower the risk of UL-WMSDs.

Thus, considering the many identical workstations in the production sectors of this industry, it is estimated that most workers were exposed to medium risk. This presents two to four times greater probability of developing UL-WMSDs than the population that was not exposed.

More studies are needed to determine whether the present findings can be generalized to other pig slaughterhouses, given that the current study was limited to analyzing only those workers within a Brazilian slaughterhouse.

Finally, some organizational measures should be considered to lower the risk of UL-WMSDs: reducing the work pace; adopting well-distributed rest breaks throughout the workday (preferably hourly); adopting job rotations between tasks with different biomechanical requirements; increasing the number of employees; using sharp knives to reduce the effort required to perform cutting tasks; decreasing the use of knives, and monitoring the risk level of work activities through objective tools such as the OCRA Checklist.

ACKNOWLEDGMENT

This research was funded by "Sistema Integrado de Gestão Ergonômica e de Vigilância em Saúde em Empresas de Abate e Processamento de Carnes (SIGEVIS)" – "Fundação de Ensino e Engenharia de Santa Catarina (FEESC)" – Federal University of Santa Catarina – Brazil.

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