

Relationship between productivity, quality and musculoskeletal disorder risk among deboning workers in a Chilean salmon industry

Ilardi, Juan S.^{a,*}

^a *Physical Therapist, MSc in Ergonomics, Ergonomics Consultant, Instituto de Seguridad del Trabajo, Diego Portales Av. 2200, Puerto Montt, Región De Los Lagos, Chile.*

Abstract. The purpose of this ergonomic investigation is to establish a relationship between quality, productivity and risk of musculoskeletal disorder (MSD) in manual bone-removal process in the salmon fish industry. The method consists in a follow up study of 14 workers in a lane that processes salmon steak. Time between each steak (work cycle), quality of the steak's meat through inspection of deepness and length of the gapping generated by the manual bone-removal process and risk for musculoskeletal disorders through OCRA method were considered for this study. IMC and musculoskeletal Nordic Questionnaire of Kourinka were applied to the workers evaluated. Fourteen women worker's completed the evaluation, age 37.67 ± 8.1 , with 65.27 ± 34.41 months of experience, with an IMC of 27.18 ± 3.87 (1.52 ± 0.057 meters of height) at the time of the evaluation. Time for deboning per steak averaged 38 ± 14 seconds with 68.33 ± 14.79 steaks per hour per worker. In quality terms, 74% of the steaks were qualified as "premium steaks" and 26% as "grade or industrial" (lower category and cheapest price). OCRA index for the right hand average 13.79 ± 4.59 and 3.59 ± 0.41 for the left hand. From Nordic questionnaire 80% of the workers manifested musculoskeletal symptoms in the right hand/wrist, followed up by shoulder with 60% of the workers and arm/elbow with over 50%. There was no statistically significant relationship between productivity and quality of the steak after manual bone removal process and between quality and MSD risk. However, there was a statistically significant relationship between productivity and MSD risk ($p < 0.05$). Discussion around the results allows to see complementary results that did have strong correlation between MSD risk and the presence of lower grade salmon steaks and between areas that present musculoskeletal symptoms (MSS) and the intensity of the MSS ($p < 0.05$). The results showed that further research is needed to validate these relationships, due to the increasing demands of health-care services from this productive sector, considering its importance for this region.

Keywords: productivity, quality, musculoskeletal, disorder, repetitive, aquaculture

* Corresponding author. E-mail: jsilardi@gmail.com

1. Introduction

Aquaculture industry in the region of Los Lagos is nowadays one of the most important economic activities, providing employment to thousands of people in the region. This industry has experience changes, including its great industrialization in the 1970's, and of course, its greatest crisis due to the appearance of the infectious salmon anemia (ISA) by the year 2007-08 [17].

This latest crisis motivates companies to develop new strategies in both the industrial hygiene as the best use of the products [17].

The production of salmon, sliced or in fillets depends of various processes which include the use of important manual skills related to the use of tools such as knives and tweezers.

Quality and productivity are directly dependent on the skills of workers to process the pieces of salmon, where trimming and deboning become tasks that have a major role. Also, these tasks contain the highest risk for musculoskeletal disorders (MSD) due to the high frequency movements required by the upper limbs and a high amount of force that must be applied when using manual tools [1,7,8].

It is also important to consider other conditions in which deboners work, such as static postures for long periods (postural work-load), cold environments (that involve manual dexterity, sensitivity and accuracy), wet floors (risk for slips and falls and for the transmission of low temperatures through the boots) and night shift work as potential risks for the appearance of work-related musculoskeletal disorder (WMSD) [2,6,7,9,11,14].

The purpose of this ergonomic investigation was to establish a relationship between quality, productivity and risk of musculoskeletal disorder (MSD) in manual bone-removal process in the salmon fish industry.

2. Method

14 of 24 female right-handed workers were selected randomly to participate in the study, after giving their informed consent to participate. People who ended the study aged 37.67 \pm 8.1 years, with an IMC of 27.18 \pm 3.87, 1.52 \pm 0.05 meters tall and with an experience deboning of 65.27 \pm 34.41 months.

In a first stage, work was evaluated through the *Occupational Repetitive Action* (OCRA) method with a one hour follow-up register of actions, postures and

perceived exertion (Borg scale). Soon after this register, workers answer a *Nordic Musculoskeletal Questionnaire of Kuorinka*.

Three previous follow-up studies were conducted for a fully comprehension of the characteristics of the task to focus this next analysis.

As the purpose of this investigation was to find if it is possible to link productivity, quality of the debone process and its risk for WMSD, the analysis of the variables studied was made through a correlation matrix created with the software "Statistica 7".

Finally, risk for WMSD evaluated through OCRA methodology and using data collected where analyzed through the software ErgoMET 2, developed by the MAPFRE Ergonomics Institute, S.A.

3. Results

3.1 Production

From the follow up study on the 14 workers whose principal activity was deboning, they manage to process successfully 530.66 \pm 219.22 steaks per workday (as a team), and the time needed to debone a salmon steak was of 44 \pm 16 seconds, this is equivalent to 68.33 \pm 14.79 steaks per hour per worker (from a total of 1025 fillets observed).

3.2 Quality

The shredded of the fillets meat or the deeper the gap it gets, the lower the quality of those steaks of salmon, which means that the value of the fillets may vary. Soon after the deboner processes the pieces, these are inspected looking for a gap larger than 10 cm, an indicator that helps the classification of the fillet.

The observations showed 70.24% of the fillets were qualified as "premium" and 29.76% as "grade or industrial" (lower category and cheapest price). This means that from the 1025 fillets observed, 305 suffer a gap due to the use of the tweezers on them for the fishbone removal, shredding its meat.

3.3 Risk for WMSD and discomfort

OCRA index for 13.79 \pm 4.59 for the right upper limb (RUL) and 3.59 \pm 0.41 for left upper limb (LUL). Results for RUL indicate "very high risk" for

WMSD, achieving a red flag. Results for LUL indicate “low risk” for WMSD.

Musculoskeletal comfort measured through *Nordic Musculoskeletal Questionnaire of Kuorinka* showed that 80% of the workers manifested symptoms in the

right hand/wrist, followed up by shoulder with 60% of the workers and arm/elbow with over 50%.

Table 1

Correlations. Marked correlations are significant at $p < ,05000$ $N=14$. (a) total fillets deboned per worker per hour, (b) fillets which suffer a gap greater than 10 cms. (c) fillets which suffer a gap shorter than 10 cms. (d) OCRA index result for left hand, (e) OCRA index result for right hand, (f) low gapped fillets divided by the total fillet deboned in percentage terms, (g) lifetime experience deboning in months, (h) areas of the Kuorinka nordic questionnaire body map which present musculoskeletal discomfort, (i) intensity of discomfort from 0 to 5 in a visual analog scale, (j) Body mass index, and (k) age of the worker

	Deboned fillets	High gapping	Low gapping	OCRA I	OCRA D	Efficiency	Experience	Areas with MSD	Intensity of MSD	BMI	Age
Deboned fillets(a)	1,00	0,39	0,85	-0,10	0,55	0,06	-0,37	0,11	-0,02	-0,35	-0,28
High gapping(b)	0,39	1,00	-0,15	0,26	0,60	-0,87	-0,00	-0,01	0,28	-0,01	0,03
Low gapping(c)	0,85	-0,15	1,00	-0,25	0,25	0,56	-0,39	0,13	-0,18	-0,37	-0,32
OCRA left hand(d)	-0,10	0,26	-0,25	1,00	0,34	-0,24	-0,09	0,05	0,20	0,08	0,42
OCRA right hand(e)	0,55	0,60	0,25	0,34	1,00	-0,27	0,04	0,02	0,06	-0,05	-0,19
Efficiency(f)	0,06	-0,87	0,56	-0,24	-0,27	1,00	-0,09	0,16	-0,19	-0,16	-0,20
Experience(g)	-0,37	-0,00	-0,39	-0,09	0,04	-0,09	1,00	0,28	0,16	0,31	0,46
Zones with TME(h)	0,11	-0,01	0,13	0,05	0,02	0,16	0,28	1,00	0,73	-0,31	0,39
Intensity of MSD(i)	-0,02	0,28	-0,18	0,20	0,06	-0,19	0,16	0,73	1,00	-0,20	0,18
BMI(j)	-0,35	-0,01	-0,37	0,08	-0,05	-0,16	0,31	-0,31	-0,20	1,00	0,03
Age(k)	-0,28	0,03	-0,32	0,42	-0,19	-0,20	0,46	0,39	0,18	0,03	1,00

4. Discussion

It is known that repetitive tasks have a high risk for the occurrence of musculoskeletal disorders. In this line, it was possible to link individual production to this particular risk, but it was not possible to link efficiency with the risk of MSD and/or with individual production.

However, it was possible to see a trend in the correlations, shown on table 1, of other factors influencing individual production such as experience in deboning, risk for WMSD and age.

It is interesting that production, in a way, it is quite reachable by deboners during a whole shift period, but with an enormous variability intra-worker and inter-worker, identifying individual productions from 55 to 85, higher than the 50 to 70 fillets deboned established by the company.

It is clear that a bigger sample will be necessary to confirm the results, and of course, studies that

include, in an integrated way, the study of other ergonomic factors.

During the field data collection and further analysis, it was possible to find a loss of a considerable amount of money because of the gapping and shredding of the fillet due to bad technique of deboning. This condition, if improved, could mean the recovery of US\$ 2.03 (top) per hour per worker, considering that in a daily shift there are almost two hundred workers and half of that number by the night shift.

From the experience gained during this research, it was possible to recognize a series of working conditions that are easily upgradeable with small steps which could allow a better quality of working life, but also performance or efficiency of the process of deboning. Considering, the amount of money saved through a better yield of the products and a lower rate of WMSD.

Some other factors should be included in future investigations such as the effect of the ambient in this

work, psychosocial factors or contextual factors. While the salmon industry offers a lot of jobs, nowadays these jobs are considered seasonal, depending on the maturation of the salmon in their farms. At the time of the investigation, a high production season was on stage, having lots of active workers. The problem with these high-demand seasons, appears when production demand is so high that workers cannot maintain the pace of work, significantly increasing musculoskeletal injuries in the upper extremities, leaving people with a deterioration, not always successfully recovered before re-applying for jobs in these companies, causing a migration of people to companies in which they have no history of them and their injuries. Obviously, this situation will not last forever.

5. Conclusion

5.1. Productivity

Considering standards established by the company, an average of 50-70 fillets deboned per hour worked (this depending on the *rigor mortis* of the meat related to death time of the fish), follow up data showed that average individual production of deboned fillets was 68.33±14.79 per worker, considering the product was a *salar salmon* (soft meat with enough death time for a low *rigor mortis*).

According to the results, the greater the individual production the greater the risk for the occurrence of musculoskeletal injuries for the right hand (table 1).

5.2. Efficiency

Efficiency was used as a quality indicator, considering fillets with a low gap over the total amount of fillets deboned per hour per worker. However there was no significant correlation between efficiency and productivity or WMSD.

5.3. Work-related Musculoskeletal Discomfort

The application of the *Nordic Musculoskeletal Questionnaire* showed a strong correlation indicating that the more areas that present discomfort, the greater the intensity of discomfort.

5.4. Quality and productivity

The correlation between quality (amount of gapping on the fillet) and productivity (amount of deboned fillets per hour per worker), showed no significant relationship.

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