



A Presentation of the Ergonomic Analysis of Risk Factors in Productive Sectors of Chile and Their Relation with Upper Limb Musculoskeletal Symptomatology

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Abstract. This study aims to identify musculoskeletal health conditions present in a population that works in several different productive sectors in Chile in order to determine the physical risk factors in that type of labor and relation between these risk factors and upper limb musculoskeletal symptomatology. An analytic, nonexperimental, transversal association study was carried out with a sample of 390 worker's tasks, confidence level of 95%, standard deviation of 5% and maximal variability. Representative task per trade-workers of six different sectors was evaluated. Results describe most representative physical risk factors. In industrial sector were: posture and strength; in service sector: repetitive movement and force factors; in mining sector: repetitive movement and posture and strength; in agriculture sector: repetitive movement, posture and recovery time; in construction sector: posture, repetitive movement and strength; in aquaculture sector: repetitive movement and recovery time. There was a high prevalence of musculoskeletal complaints, of 69,74% in the sample evaluated with Nordic Musculoskeletal Questionnaire. There was no association between musculoskeletal health condition and identification of risk factors (Fisher p-value 0,587). Statistically significant association was found between physical risk factors identified and specific productive sectors chosen (p-value = 0.0001). There is a high prevalence of musculoskeletal symptoms in all productive sectors studied. Productive sectors that present most specific risk factors are Aquaculture, Agriculture, and Industry Sector and this translates into a high prevalence of physical risk factors. The model of the applied tools is efficient to perform the surveillance of the ergonomic risk factors and the musculoskeletal health condition.

Keywords: Ergonomic risk factors · Upper limb
Work-related musculoskeletal disorders

1 Introduction

In Chile, the risk prevention regarding work-related musculoskeletal disorders is regulated by the Supreme Decree N° 594 [1] and Law N° 16.744, on accidents and profession-related illnesses [2]. In September of 2012, the Ministry of Health in Chile published the Technical Norm for the Identification and Evaluation of Risk Factors in Work-Related Musculoskeletal Disorders in Upper Limbs, denominated the TMERT-EESS Norm.

The Technical Norm for the Identification and Evaluation of Risk Factors in Work-Related Musculoskeletal Disorders in Upper Limbs relies on an instrument for “Risk Identification and evaluation” that was developed based on criteria given by the ISO Norm 11228-3 for the evaluation of task with a low load and high frequency [3, 4].

Based on the last National Labor Condition Survey in Chile [5], it is observed that among the main risk factors identified in the companies surveyed. The ergonomic risks are found in a 32% of the companies. In the Agricultural Sector, a 24,3% of the companies presented ergonomic factors; in Services, there was a 37%; in Industry, a 27,3% and in the Construction Sector, there was a 26,7% of ergonomic factors. Also, there is a great number of workers exposed to ergonomic risk factors depending on the productive activity.

In the Agricultural Sector there are 824,79 thousand persons; in Services, which considers several branches, there are over 950 thousand affected persons; in the Industrial Sector, there are 886,89 thousand persons, and in Construction, there are 712,95 thousand persons exposed to risk factors. In relation to those persons occupied by an economic activity in the selected sectors, as a whole, represent approximately a 35% of those employed on a national level according to the data given by the National Institute of Statistics for the first trimester of 2017 [6].

The health surveillance of the workers that depend directly on the objectivity of the information obtained from the evaluation of the risk levels to which the workers are exposed. For this, it is also necessary to know more about the relationship that exists between the exposure to risk factors and the development of symptomatology, and, subsequently, the musculoskeletal pathology.

The public institutions in Chile, related to the regulation of Occupational Health matters, note in their statistics that there is a high prevalence of upper limb musculoskeletal illnesses related to work conditions. This is why it is relevant to know the specific manner in which risk factors that are present as well as the specific health condition that is musculoskeletal. This will allow for the development of specific strategies and actions for the correction and prevention of musculoskeletal disorders.

2 Methodology

For this present study, we are using a database built by the Ergonomy Laboratorio of the Universidad de Chile, which is based on a study of work conditions carried out during a period of 18 months. The data obtained from the database takes into account an analytical, nonexperimental, transversal association study base. All the data obtained

by the workers, their trade and main tasks in the Industry, Aquaculture, Agriculture, Service, Mining and Construction Sectors will be taken into account.

The data obtained considers the study of 390 tasks (Unit of Analysis) and workers (Unit of Sampling), the tasks that are sampled considered workers and main tasks according to the productive sector and company. The sampling strategies from which the data is obtained in order to characterize the exposure to factors of ergonomic risk during the execution of their tasks. For this, the criteria of inclusion that are considered are tasks that involve the use of upper limbs that take place in the selected labor Sectors.

The data obtained from a stratified sampling according to region and area. The assignation of the social stratum were appointed freely with a minimum of 30 workers per stratum. The sampling size is of 390 and it is calculated by considering a trust of 95%, an error of estimation of 5% and a maximum variability. In the sample, the tasks considered are the most representative in each field, by the workers, in which there is an exposure of upper limbs to ergonomic factors such as repetition, posture, force and recovery periods.

In order to carry out this ground work, a fieldwork protocol was designed, as well as the necessary materials, the acceptance letters for the participation of the selected companies and the consent forms to be signed by the worker. We carried out the test planning on site. The evaluations were effected by specialist of the Universidad de Chile and engineers in prevention from the studied companies.

The obtainment of the data comes from a study of exposure of the worker to his task, studied with an observational method, which is a model developed for this purpose. The field protocol from which this information is obtained included a brief interview to the worker, task analysis, graphic records and the preliminary identification and evaluation of the risk. This preliminary evaluation of risk is carried out through the on site application of the evaluation instrument, according to the current norm in Chile (Check list TMERT) and the musculoskeletal health condition that was evaluated by the Nordic Kuorinka questionnaire, currently in force in Chile.

3 Results

3.1 Sample Description

The treatment and result analysis consider the systematization of the database information, process done by the SPSS System, based on the description of the results through descriptive statistics and the application of statistic tests such as the Fisher Test and Chi-Case for the analysis of the association of study variables (TMERT Risk factors and the Musculoskeletal Health Conditions).

The results describe that of the sample of 390 tasks studied, 59,74% correspond to tasks carried out by men and 40,26% correspond to tasks carried out by women. 92,05% of the workers present a right handed laterality. The average age of the sample studied is 38 years. In the sample studied, the average work period described is of 48 months at a given work post.

The sampling distribution considers Agriculture (12%), Service (40,2%), Construction (12%), Manufacturing Industry (20,2%), Mining (7,7%) and Aquaculture (7,7%).

3.2 Identification of Risk Factors in Studied Tasks

Exposure is described as the frequency in which risk given by repetition, posture associated to movement, use of Strength and recovery times in the studied tasks are present.

The risk factor of movement is present in 349 (85%) of the tasks, posture is present in 367 (94%) of the tasks and Strength is present in 282 tasks, which represents a 72,3%, the same as the recovery period risk factor (Table 1).

Table 1. Distribution of absolute and relative frequency of risk factors considering all studied tasks

	Repetitive movement		Posture		Strength		Recovery time	
	N°	%	N°	%	N°	%	N°	%
Present	349	89,5	367	94,1	282	72,3	282	72,3
Absent	41	10,5	23	5,9	108	27,7	108	27,7
Total	390	100	390	100	390	390	390	100

In the description of the risk factors identified, the preliminary most frequent risk level for each are analyzed. It is shown that, regarding the Repetitive Movement Risk Factor, the level of preliminary risk is on a red level; regarding the Strength Risk Factor, the most frequent preliminary level of risk is mixed (Green, yellow and red level), and finally, for the Recovery Time Risk Factor, the preliminary level of most frequent risk in level green (Table 2).

Table 2. Distribution of absolute and relative frequency of preliminary categorization of risk according to risk factors considering all studied tasks

Level risk	Repetitive movement		Posture		Strength		Recovery time	
	N°	%	N°	%	N°	%	N°	%
Green	86	25,74	109	30,8	94	33,2	112	39,8
Yellow	95	28,44	101	28,5	94	33,2	75	26,7
Red	153	45,8	144	40,7	95	33,7	94	33,4
Total	334	100	354	100	283	100	281	100

4 Level of Risk by Evaluated Area

The level of risk determined by risk factor and by area, considering the total of evaluations in which a risk factor is identified. For this, the analysis is carried out by grouping the information according to risk factor and area. It is highlighted that,

Table 3. Distribution of relative frequency according to the risk factor, level of risk and area

	Repetitive movement grouped by area			Total
	Green	Yellow	Red	
Industrial	33,9%	5,4%	60,7%	100%
Service	26,2%	36,6%	37,2%	100%
Mining	26,7%	36,7%	36,7%	100%
Agriculture	10,6%	29,8%	59,6%	100%
Construction	34,1%	24,4%	41,5%	100%
Aquaculture	6,7%	13,3%	80%	100%
Total (%)	24,6%	27,2%	48,1%	100%
	Posture grouped by area			Total
	Green	Yellow	Red	
Industrial	37,7%	24,6%	37,7%	100%
Service	34,2%	35,6%	30,1%	100%
Mining	24,1%	48,3%	27,6%	100%
Agriculture	10,6%	27,7%	61,7%	100%
Construction	34%	27,7%	38,3%	100%
Aquaculture	17,9%	14,3%	67,9%	100%
Total (%)	29,8%	30,9%	39,3%	100%
	Strength grouped by area			Total
	Green	Yellow	Red	
Industrial	47,5%	24,6%	27,9%	100%
Service	35,6%	40,6%	23,8%	100%
Mining	20,7%	44,8%	34,5%	100%
Agriculture	29%	16,1%	54,8%	100%
Construction	30%	40%	30%	100%
Aquaculture	5%	15%	80%	100%
Total (%)	33%	33%	34%	100%
	Recovery period by area			Total
	Green	Yellow	Red	
Industrial	42,9%	16,3%	40,8%	100%
Service	46,9%	16,3%	40,8%	100%
Mining	31,6%	47,4%	21,1%	100%
Agriculture	32,5%	17,5%	50%	100%
Construction	38,u%	45,2%	16,1%	100%
Aquaculture	24,1%	20,7%	55,2%	100%
Total (%)	39,9%	26,7%	33,5%	100%

in relation to the repetitive movement, as a risk factor, is frequently present in the Manufacturing, Agricultural and Aquacultural Industry. The Posture Factor is notable as it is relevant in the sectors of Agriculture, Aquaculture and Manufacturing Industry. The risk factor of Strength is notable as it is relevant in the Aquaculture, Agriculture and Mining Sectors. Finally, the Period of Recovery Factor is relevant in the Aquaculture, Agriculture, and Industry Sectors (Table 3).

4.1 Description of Musculoskeletal Health

It is determined that the sample studied presents a high prevalence of musculoskeletal discomfort, manifesting musculoskeletal discomfort in at least one segment is 69,74%. Of this general information, 39,74% of the evaluated workers present pain in the right hand/wrist segment, 33% present pain in the right shoulder, 28,21% in the neck, 24,36% in the left hand/wrist, 20,51% in the right elbow and forearm, 19,23% in the left shoulder and 12,05% have pain in their left elbow and forearm (Table 4).

Table 4. Distribution of absolute and relative frequency of the presence of musculoskeletal discomfort such as pain, numbness or tingling sensation according to body segment in the last 12 months according to Nordic Questionnaire in the population sample of 390 workers

Segment	Nº	%
Neck	110	28,21
Right shoulder	130	33,33
Left shoulder	75	19,23
Right elbow/forearm	80	20,51
Left elbow/forearm	47	12,05
Right hand/wrist	155	39,74
Left hand/wrist	95	24,36

When the Nordic Questionnaire evaluation instrument was applied, it also explored the presence of the perception of musculoskeletal discomfort in the last seven days. The results describe a result similar to that which was presented in relation to the consult of the last twelve months. A 23,59% of the sample is described as having presented discomfort in the right hand/wrist and a 14,62% of the sample presents the perception of musculoskeletal discomfort in the last seven days in the right shoulder.

The following table (Table 5) determines the presence of Incapacity Associated to pain, by segment and average of pain perceived. The pain is evaluated through a visual analog scale of 10 points.

Table 5. Distribution of absolute and relative frequency according to the presence of musculoskeletal discomfort during the last seven days en average of the assessment of pain in each segment of the whole of the subjects evaluated

Segment	Nº	%	Average EVA pain
Neck	55	14,10	4,35
Right shoulder	57	14,62	4,12
Left shoulder	55	14,10	4,36
Right elbow/forearm	43	11,03	4,44
Left elbow/forearm	26	6,67	4,50
Right hand/wrist	92	23,59	4,45
Left hand/wrist	57	14,62	4,44

In relation to the association between the risk factors identified (by the checklist of the Technical Norm) and the musculoskeletal health condition represented by the Nordic Questionnaire is described by the following results:

Considering the results of the identification of the risk factors and the presence of the musculoskeletal discomfort in the last twelve months is described as not having an association between the identification of the risk factors of Repetitive Movement, Posture, Strength and Recovery Time, with the musculoskeletal health condition (Table 6). In general terms, there is no existent association between the presence of risk factors and the musculoskeletal discomfort, given a Fisher p-value 0,587.

Table 6. Results of the association between the identification of the risk factors and the presence of the musculoskeletal discomforts in the last twelve months

	Perception of musculoskeletal discomfort in the last 12 months	
	Chi/Fisher	P value
Repetitive movement	2,7	0,07
Posture	2,02	0,119
Strength	0,006	0,514
Recovery period	0,435	0,298

The results, considering the grouping of the information linked to the identification of the risk factor, level of the preliminary evaluation of risk and area, describe that there is an association between the preliminary level of evaluated risk of each risk factor by means of the TMERT checklist and the specific studied areas. In this sense, the association of the identification of the risk factor with the areas allows noting that the characterization of the different areas is achieved with the applied instrument (Table 7).

Table 7. Results of the association between risk factors, preliminary evaluation of risk and area

	Area	
	Chi	P value
Repetitive movement	43,366	0,0001
Posture	33,711	0,0001
Strength	40,367	0,0001
Recovery period	28,717 (Fisher)	0,0001

5 Conclusion and Discussion

There is a high prevalence of musculoskeletal symptomology in all the productive sectors studied, as well as there is a high prevalence of TMERT ergonomic risks [7].

The factors that stand out in relation to the prevalence of risk factors of TME are the risk factors of Repetitively and Posture. The Aquaculture, Agriculture and Industrial Manufacturing Sectors present high prevalence in the different factors studied.

We conclude that there is no existent association (possible relations) between the conditions of musculoskeletal health and the identification of risk factors. It is noteworthy that the second stage of progression of the disorder was also evaluated, which corresponds to the perception of musculoskeletal discomfort, diagnosed cases have not been evaluated [8, 9].

It is also notable that the epidemiological evidence establishes a high fraction that is attributed to these risk factors and the development of the musculoskeletal disorders on the level corresponding to the upper extremities [10, 11]. With this, it can be concluded that we may face the presence of many potential cases of future work-related musculoskeletal disorders in the sectors that were studied, which is why prevention strategies and actions must be reinforced.

The checklist of the TMERT Norm, as well as the Nordic Questionnaire, are efficient tools to develop the activity of surveillance of the risk factors, understanding that they are not specific tools of evaluation as much as they are surveillance tools that use the preliminary identification of risk, to subsequently give orientation for more specific actions of evaluation.

In this context, it can be concluded that it is relevant to have public policies of adequate records and protocols of surveillance of risk factors and medical surveillance to establish health policies in the future for appropriate records classified by regions and productive areas, by establishing the relevance of the concept of sectorization of the instruments of evaluation, as well as the preventive actions.

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