Difference of Actual Handled Weight and the Recommended Limit for Dynamic Asymmetrical Manual Handling Tasks in Chilean Construction Workers

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Abstract. Manual handling is a risk factor with high attributable fraction in lumbar pain, frequent injury among construction workers due to dynamic and complex tasks. The aim of this study was to establish the differences between the actual handled weight and the recommended weight limit (RWL) according to EC2 (Ergo Carga Construcción) evaluation method.

The study was an analytic and non-experimental cross-section carried out in 32 construction sites with a sample of 186 workers. The positions assessed were bricklayer, scaffolding assembler, carpenters, hand laborers, construction laborers (excavation laborer/safety carpenter) and ironworkers during weight handling tasks. The EC2 method is designed to assess Dynamic Asymmetrical Manual Handling Tasks (DAMHT) and as result, estimates the Recommended Weight Limit (RWL) per task.

Within the group 179 DAMHT were assessed. In the sample the actual handled weight was between 3 kg and 80 kg, with a median of 20 kg (ICR = 20 kg). Meanwhile the values of the RWL were between 1.8 kg y 28.7 kg, with a median of 7.31 kg (ICR = 3.37 kg). Generally, all positions handle weights above the RWL established by EC2. The analyzed sample has a difference of 10.98 kg (ICR 23.4), between the actual handled weight and the RWL. The exception are the construction laborers (excavation laborer/safety carpenter), who present a negative difference, while hand laborers (15.69 kg/ICR 25.84), bricklayer (15.17 kg/ICR 23.28) and ironworkers (10,7 kg/ICR 24,62 kg) presents the highest difference among the group.

Contrasting research data with limits allowed by Chilean Law (Law 20.949 – maximum limit of 25 kg), a 33% of the sample performs DAMHT above lawful limits. 5% handle weights above 50 kg with a maximum of 80 kg. Regarding the RWL 83.2% of the manual handling observed is above this limit, therefore they imply high physical workload, thus the intervention must be not only with a technical approach but with administrative and engineering actions.

Keywords: Manual material handling · Construction · Ergonomics

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1 Introduction

Based on the epidemiological evidence, the risk factor for Manual Material Handling (MMH) has a high attributable fraction in the thoracolumbar disorders. Particularly in the construction sector, there is a high presence of tasks with MMH in the construction processes and their various phases, such as the earth movement phase, structure phase, closing phase and finishing phase. Due to the above, this productive sector becomes a vulnerable sector for the development of musculoskeletal disorders (Buchholz et al. 1996; Punnet and Wegman 2004; Umer et al. 2018). In this context, it has been observed that some work-related tasks in the construction sector represent a high physical workload which increases the risk of suffering musculoskeletal disorders in the lower back. Therefore, ergonomic measures should be implemented to decrease the appearance of these musculoskeletal disorders (Villumsen et al. 2016).

Based on national studies, it is described that a high percentage of workers are exposed to ergonomic factors represented by 32% of companies, where MMH is a relevant risk factor. In the last National Survey of Labor Conditions (Encuesta Nacional de Condiciones de Trabajo - ENCLA) of the Government of Chile in the construction sector, 26.7% of companies reported to have ergonomic risks (Dirección del trabajo 2014). That is why, in the construction sector, the identification and evaluation of risk factors associated with the physical workload (with an emphasis on MMH) are relevant, to improve preventive actions and strategies in the different tasks. Moreover, in the specific offices that act in the building construction process.

Musculoskeletal disorder (MSD) is one of the main problems faced by construction workers, who, due to the nature of their physical work, show a significantly higher prevalence of MSD in different regions of the body. In many types of occupational groups, MSDs are the leading causes of work-related disability and time lost due to illness (Chang et al. 2009).

Among workers in the construction sector, there are high rates of injuries that outnumber workers in other areas of work, so this sector continues one of the most risky sectors due to its association with a high incidence of deaths and injuries (Leung et al. 2012; Yi and Chan 2016).

1.1 Dynamic-Asymmetric Manual Material Handling

The most common operations carried out in the construction sector in specific housing and commercial building construction, involves MMH, especially in tasks related to scaffolding, formwork, steel structures, masonry, construction fabrics, plumbing, suspension of ceilings and pavements (Albers et al. 2005; Albers and Estill 2007).

In critical sectors such as Construction, processes are presented characteristically with variable work cycles and multiple incident variables, and which, as a whole, will condition the process of evaluating the “ergonomic” risk to determine the Physical workload, as well as the risk of developing MSD.

In this productive sector the MMH tasks are often from a “Dynamic-Asymmetric” nature. The common denominator is the execution of MMH with lifting, transport and deposit in continuous form, as well as, executed in perimeters greater than two meters from where the activity originates.

This presents a difficulty for the evaluation because these instruments do not manage to objectively determine the risk. An evaluation process must be structured that considers specific variables, with an evaluation approach oriented to the study of tasks with dynamic asymmetric manual material handling (Cerda 2006, 2013).

1.2 Weight Handled

In September 2017 in Chile, the Law 20.949 came into force. Modifying the Labor Code and the maximum weight limit allowed at the national level, currently up to 25 kg, for the male adult population. This legislative change is in accordance with the provisions of ISO/TR 12295: 2014, which establishes the 25-kg limit as a critical condition in tasks that involve lifting and transporting materials for male subjects between 18 and 45 years old (ISO 2014).

In the literature, there is a vast number of investigations related to the different risk factors that influence the handling of materials and the potential development of MSD. Among them are: lifting frequency, grip, asymmetric posture, vertical and horizontal lifting distance, transfer distance and, of course, the weight of the handled material. In construction activities involving MMH are also carried out in extreme environmental conditions, with postural limitations, high repetition and high weight of materials, tools and equipment (Ray et al. 2015). Generating high stress on the lumbar spine at segments L5/S1 level based on biomechanical studies performed on construction workers (Ray et al. 2015), in addition to a more significant increase in energy expenditure (Villagra 2000).

In Construction sites the handled materials have different sizes and weights. In Brazil, for example, the loading and unloading of 50 kg bags of cement and loaded trolleys with 49.7 kg on average have been studied to determine risk (Debiase et al. 2015). Construction workers have pointed out in studies utilizing surveys, that they handled weights around 15 kg on average per day (Fang et al. 2015). Likewise, it has been established in investigations that bricklayers handle weight between 2.5 kg and 10 kg of weight in stonework masonry (Villagra 2000). Scaffolding assemblers, while manipulating 17.3 kg or more, when building conventional brick walls (Hess et al. 2012). Given the risk represented by the weight handled, it is essential to accurately determine the handled weight limit to avoid overexertion (Lee 2012).

Based on what has been described, the development of this study is aimed at establishing differences between the actual weight handled and the Recommended Weight Limit (RWL) according to the EC2 evaluation method, which in its evaluation strategy considers the study of tasks with manual manipulation of Dynamic Asymmetric materials in specific trades of the building construction process.

2 Participants and Methods

The study was an analytical and non-experimental cross-section. The sample was selected for convenience and in a stratified form in main trade-tasks, in a two-stage manner. Companies were selected and then obtained through the selection of trade-workers who agree to participate in the study voluntarily and who meet the inclusion criteria.

Building Construction is considered, (large companies of more than 100 workers in the Metropolitan Region and Valparaíso Region of Chile) affiliated to an Organism Administrator of Law, the Instituto de Seguridad del Trabajo (IST). Of the companies defined to capture the sample, the participation of 32 different construction works, 17 works in the Metropolitan Region and 15 works in the Valparaíso Region which are specified.

The trades evaluated were: Bricklayer, scaffolding assembler, carpenters, hand laborers, construction laborers (excavation laborer/safety carpenter) and ironworkers. A total of 186 workers were evaluated. There were six evaluations which due to lack of data in the land evaluation instruments, were not counted in the summing up of the final sample.

For the execution of work in the field, a protocol of field study, development of evaluation material is designed, as well as informed consent presented to each worker. Land test planning and training of the evaluation team was made exclusively by Ergonomists of the Universidad de Chile. The EC2 method was used, which is designed to evaluate Dynamic Asymmetric Manual Handling Tasks (DAMHT) and as a result estimates the recommended weight limit (RWL) for the task (Cerda et al. 2014).

The ethics committee approved this study in human research of the Faculty of Medicine of the Universidad de Chile.

3 Results

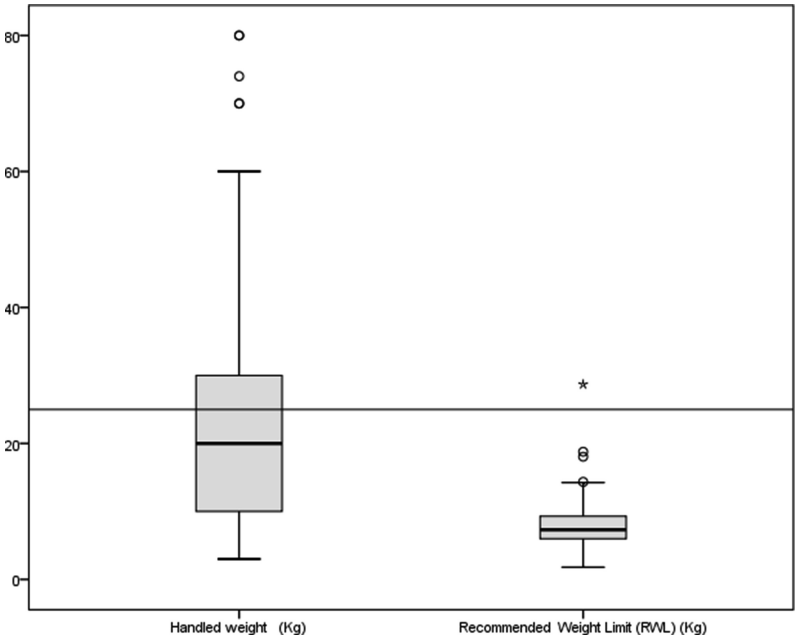
Within the group of trades, a total of 179 DAMHT were evaluated, with distribution by trades as shown in Table 1. The group of "Hand laborers" has the highest representation in the sample with 41.34%, this group, which develops all the tasks of hauling and distributing materials within the works. The group with the least representation is the "Ironworker" with a representation of 8.37%.

Table 1. Distribution of the sample evaluated by trades in the 32 construction works between the Metropolitan Region and the Valparaíso Region, Chile.

Trade	Evaluation with EC2	
	Absolute frequency	Relative frequency
Bricklayer	27	15%
Scaffolding assembler	21	11.73%
Carpenter	24	13.40%
Hand laborers	74	41.34%
Construction laborers (excavation laborer/safety carpenter)	18	10.05%
Ironwork	15	8.37%

In the total sample, the handled weight was between 3 kg and 80 kg, with a median of 20 kg (ICR = 20 kg). Meanwhile, the RWL values were between 1.8 kg and 28.7 kg, with a median of 7.31 kg (ICR = 3.37 kg) (See Graph 1).

The median for both groups, actual weight handled and recommended, are under the limit of 25 kg established by Chilean Law 20.949. It has been observed outlier corresponding to handled weights of 70 kg in two cases, 74 kg in one case and two cases with 80 kg, while, for the Recommended Weight Limit (RWL) three extreme outlier were observed. 18.05 kg, 18.78 kg and 28.69 kg, the latter exceeding the weight limit established by Chilean law.



Graph 1. Handled weight distribution and Recommended Weight Limit (RWL) established by EC2 method.

Concerning the behavior of the actual weight handled and the recommended weight limit, as well as the difference between these two indices by trades evaluated, this is detailed in Table 2.

In general, all trades handle weights above the established RWL according to EC2. The analyzed sample has a difference of 10.98 kg (ICR 23.4), between the handled weight and the RWL. The exception is Construction Laborers (excavation laborer/safety carpenter) who present a negative difference, while Hand laborers (15.69 kg, ICR 25.84), Bricklayer (15.17 kg, ICR 23.28) and Ironworker (10.7 kg, ICR 24.62 kg) present the most significant difference between the group.

Table 2. Description of actual weight handled based on a total sample, weight limit recommended by EC2 method and difference of actual weight handled and recommended weight limit calculated by EC2.

Trade	Actual weight handled		Weight limit recommended		Difference of actual weight handled and recommended weight limit	
	Median	IQR	Median	IQR	Median	IQR
Bricklayer	25	20	7,65	2,75	**15,17**	23,28
Scaffolding assembler	15	20	8,09	3,36	6,86	21,28
Carpenter	13,5	12,3	7,02	3,45	5,21	12,6
Hand laborer	24	26,5	7,1	2,92	**15,69**	25,84
Construction laborers (excavation laborer/safety carpenter)	6	17	6,79	2,51	−2,22	15,52
Ironworker	16,8	24	8,29	4,74	**10,7**	24,62

4 Discussion

The manual manipulations of a materials in the construction sector and specifically in the housing and commercial building construction sector presents specific characteristics associated with dynamism and asymmetry in the execution of tasks with MMH, in turn, present the long work cycles tasks, poorly defined variables and multiple incidents that increase the risk of musculoskeletal disorders.

In the trades studied there are risk factors associated to the materials (dimensions, weights and shapes), to the technique and postures in the execution of the tasks, the manipulation difficulties, as well as associated to the environment and job.

Based on the sampling obtained, the trades of the sector are characterized by bricklayer, scaffolding assembler, carpenters, hand laborers, construction laborers and ironworkers. In the case of ironwork trades and construction laborers (excavation laborers/safety carpenter), there is a low frequency of presentation due to the subcontracting schemes existing at the sites of the companies participating in the study; work contract strategy that responds to a model that is carried out in the world in the construction sector (Bryan et al. 2017). In this study, the trades and tasks sampled characterize the dynamic system associated with the time of permanence in the work and linkage with a major company or subcontracted companies.

In relation to the results, they express the assessment of the handled weight. In general, they are below the maximum allowed limit. However, emphasis is placed on the point of analysis, that being under the weight limit established by the Law (in this case under 25 kg) does not imply that there is no risk since the context and conditions of how the task is performed must be considered based on the worker-environment relationship being able to, therefore, be an acceptable or unacceptable level of risk according to each case and with the same material for example.

Nevertheless, multiple analysis models calculate the risk based on different variables and their weighing factors for calculating the recommended weight limit. The most traditional being weight, vertical distances, horizontal distances, frequency, manual handling and grip. In this case, it is worth noting that the recommended weight limit (RWL) considers specific variables in the interpretation of risk for tasks with manual manipulation of dynamic-asymmetric loading. Some of these variables being relevant to weight, handling techniques (arm segment), manipulation posture (trunk segment), frequency, difficulty of manipulation (infrastructure, distances and organization), combined control and perceived effort (Cerda et al. 2014).

Concerning the weights handled, the trades, which have the most difference between the actual weight handled and that recommended by the method, are hand laborers (15.69 kg), bricklayer (15.17 kg) also ironworkers (10.7 kg). The only trade which presents a handled weight close to the recommended limit is the construction laborers (excavation laborer/safety carpenter). However, all are under the limit established by Chilean and international regulations for cargo handling (ISO 2014; MINTRAB 2018).

In this context, it is relevant to consider in the prevention of musculoskeletal disorders a dynamic model oriented to the understanding of the dynamic-asymmetric tasks of manual handling of cargo.

5 Conclusion

The approach in the identification and evaluation of risk in tasks with DAHM Tasks must consider the differentiation between this type of tasks and "more defined" tasks of manipulation that can be approached with traditional methodologies. In this context, considering that this work emphasis was placed on fulfilling the recommended weight limit with the actual manipulation and contrasting the research data with the limits allowed by Chilean Law (Law 20.949 - updated 2017, maximum limit of 25 kg), 33% of the sample performed DAMHT over the legal limits and 5% handled weights of over 50 kg with a maximum of 80 kg.

On the other hand, with respect to the RWL, 83.2% of the manual handling observed is above this limit, which implies a tremendous physical workload, so the intervention must not only be with a focus on the technique of manipulation, but rather a systemic approach where aspects of difficult manipulation such as; distance, obstacles, environmental characteristics, the perception of effort, the combined grip, considered with greater emphasis a prevention and correction approach oriented to administrative measures, work organization, to the incorporation of specific technical aids for the sector and as well as engineering measures.

Finally, based on the results obtained, it can be concluded that both in the normative instruments of the different countries, as well as in the supporting technical documents for the evaluation of the risk in manual handling tasks, an analysis must be considered. Differentiated in the different tasks with manual load handling, differentiating the analysis in those cases with Dynamic Asymmetrical Manual Handling Tasks through models adapted for the specific study of said condition.

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