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A REBA-BASED ANALYSIS OF PACKERS WORKLOAD: A CASE STUDY

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ABSTRACT. Background: One of the elements of a logistics system is the subsystem of production, which is a system composed of physical elements such as machinery, tools and (most importantly) people. In addition, system-dependent human operators are particularly prone to problems related to discomfort, which can affect production quality and increase training costs and absenteeism. The aim of this study was to assess the workload and risk of musculoskeletal discomfort (MSD's) in the process of order fulfillment for the position of packer and to conduct an analysis of risk factors.

Methods: The Rapid Entire Body Assessment (REBA) evaluation method was used. Activities related to the fulfillment of an order were assessed for three workstations.

Results: Five postures qualified for action category (AC) 2, seven postures for AC 3 and one posture for AC 4. The main factors affecting the risk of a negative assessment of posture were keeping the back bent and twisted, keeping the arms raised above the trunk, working in a standing position and the weight of packaged carton.

Conclusions: Packers working on research positions face a high level of exposure to the risk of MSD's, therefore corrective actions should be carried out as soon as possible. Ergonomic intervention should be linked to redesigning workstations and methods of working. After making changes to the research workstations, re-evaluation using the REBA method is recommended to verify the effectiveness of the changes.

Key words: REBA, workload, ergonomics, risk, MSD's.

INTRODUCTION

One of the elements of logistics systems is the subsystem of production [Słowiński 2008] and the basic elements (resources) of each work process comprise of people, means of labor and objects of labor [Słowiński 2008]. Production systems are defined as a complex system of physical items such as machinery, tools and (most importantly) people. Employees in manufacturing systems are "internal consumers" and the system must be designed to meet their needs. At the same time, production systems must produce goods that meet the needs of "external consumers". In terms of health and safety, the production system is designed to meet the needs of both internal and external consumers [Black 2007]. In addition, production systems dependent on a human operator are particularly prone to problems related to discomfort, which can affect production quality and increase the cost of training and absence from work [Kasvi et al. 2000].

Work performed by people is accompanied by physical activity, which can cause the appearance of musculoskeletal discomfort (MSD's) among workers [Vieira, Kumar 2004]. Studies have shown that the position of the employee whilst working, range of motion, force, repetition and duration must be taken into account when categorizing the level of physical activity [Kumar 1994]. The body and movements of the operator during operation

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are important variables that must be taken into account in safety at work because they are the two most important factors in determining the workload on the employee. The position of an employee at work is affected by factors such as job done, nature of work, tools used, tool design and the anthropometric characteristics of workers [Vieira, Kumar 2004, Westgaard, Winkel 1997].

Research techniques proposed to estimate the level of discomfort and the posture's workload associated with the worker's adoption of different positions during labor can be divided into observational and device-based techniques. In the case of observation techniques, angular deviation of body sections from the neutral position is obtained by visual observation. However, for techniques based on instruments, continuous position monitoring is conducted by devices connected to the worker. Due to the lack of integration in the labor process, low cost and ease of use, observational techniques are more widely used in industry [Genaidy et al. 1994].

Observational methods used to assess postural worker load include, amongst others the Ovako Working posture Analysis System (OWAS) [Karhu et al. 1977, Kivi and Mattila 1991], Rapid Upper Limb Assessment (RULA) [McAtamney, Corlett 1993] and Rapid Entire Body Assessment (REBA) [Hignett, McAtamney 2000]. They have been developed for different purposes and are therefore used under different workplace conditions [Kilbom 1994]. Each technique has its own approach to system operator classification, which differs from other techniques. Variance may arise in the final result for operator load, depending on the technique used.

The publication of several scientific studies has shown the usefulness in assessing operator position while working in different environments such as warehouses [Torres, Vina 2012], construction [Kivi, Mattila 1991, Li, Lee 1999], agriculture [Gangopadhyay et al. 2006], forestry [Calvo 2009], supermarkets [Carrasco et al. 1995, Coyle 2005, Ryan 1989], the poultry industry [Scott, Lambe 1996], operation and maintenance of ships [Joode et al., 1997], beverage distribution centers [Wright, Haslam 1999], metal processing [Gonzalez et al. 2003], wood [Jones, 2007], stone carving [Mukhopadhyay, Srivastava 2010)], truck drivers [Massaccesi et al. 2003], fish processing [Quansah 2005], cleaners in an office environment [Kumar 1994], computer operators [Pillastrini et al. 2007, Shuval, Donchin 2005], firefighters and emergency medical technicians [Gentzler, Stader 2010], in the steel industry, electronics, automotive and chemical industries [Kee, Karwowski 2007, Kee et al. 2011, Lasota 2013a, Lasota 2013b, Muthukumar et al. 2012, Sesek et al. 2004, Wang et al. 2012], appliance manufacturers, plastics and composites manufacturers [Chiasson et al. 2012], etc. The approach has also been used in redesign and simulation in areas such as design and modeling using a digital human model [Lamkull et al. 2009, Minami et al. 2009], virtual modeling [Hirose et al. 1995], job design [Cimino et al. 2009, Hallbeck et al. 2010], design of assembly systems [Battinii et al. 2011], etc.

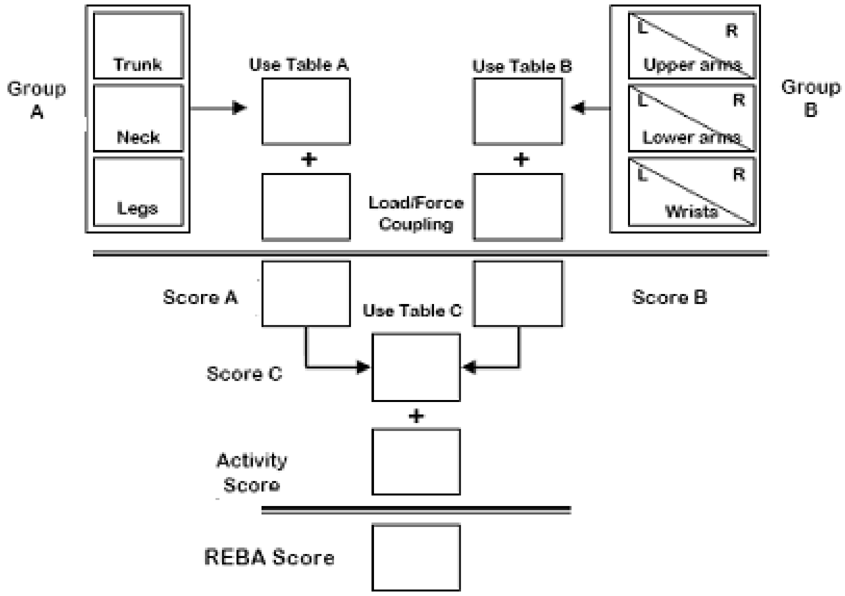
The aim of this study was to assess the workload and the risk of MSD's in the process of order fulfillment for the packer position and to conduct an analysis of risk factors using the REBA method.

METHODS AND MATERIALS

REBA method

The REBA method was developed in 2000 [Hignett, McAtamney 2000) and distributed in many countries. It is designed to assess the risk exposure associated with MSD's based on the posture of the operator at work. The method comprehensively considers the issue based on the observation of techniques used in performing the work activities. It takes into account the body postures taken by the employee during physical work, distinguishing the following segments: trunk, neck, legs, upper arms, lower arms and wrists. Also included are load/force required, hand-object coupling used and an activity score (static postures held repetition, large rapid changes in postures, or unstable base). The basis of the assessment of the degree of exposure is the aggregate position of the body and the rest of the REBA score gives scores divided by body group; score A is established by Neck, Trunk and Leg Analysis, score B is established by

Arm and Wrist Analysis, score C is given by score A and score B combined and the final score is then created from score C with adjustment according to Figure 1.



Source: Hignett i McAtamney 2000

Fig. 1. Reba score system
Rys. 1. Ocena metodą Reba

Based on the resulting final score, the risk of exposure to MSD's, Action Categories (AC) required for the improvement of working conditions on the assessed position can be classified. The authors singled out the following action categories:

- AC 0: negligible exposure, corrective actions are not required;
- AC 1: low exposure levels, corrective action may be required;
- AC 2: medium level of exposure, corrective actions are required;
- AC 3: high level of exposure, corrective action required soon;
- AC 4: very high exposure levels, corrective action required immediately.

Assessment system

The study was conducted in a company that sells books in a chain of stores and via the Internet. Some positions were in their main warehouse where the goods were prepared for subsequent purchase in stores, and also for orders made via the internet or directly at the store. Process analysis was conducted for subsequent order fulfillment actions consisting of:

- order picking,
- carton sealing,
- sorting parcels.

These positions were located on a conveyor belt. The work takes place in a standing position, from Monday to Saturday in three shifts of 8 hours working time.

RESULTS AND DISCUSSION

In the position of Order Picker (Table 1) five operator body postures were observed. In the case of the operation of collecting the carton and depositing the order ready for wrapping and taping, the risk of exposure to MSD's was high - AC 3 - which requires ergonomic correction soon. The high level was due to the need to maintain a stable upright posture while working, tilt the body, especially for the collection of the carton from the floor, and a high involvement of the upper limbs in the performance of the task. For other activities, the risk of MSD's is classified as medium, AC 2, and in the case of collection of the order - from the left side of the body - is low, AC 1. The most vulnerable segments of the body to injuries arising were the thorax, which was usually tilted heavily forward, or twisted to the side; legs - due to the standing nature of the work; arms - most were at a greater distance from the axis of the body, elevated at the shoulder joint, and frequently bent and twisted wrists.

Table 1. Position: Order fulfillment
Tabela 1. Stanowisko kompletowania zamówień

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining ist of ordered products	4	1	5	3	5	3	5	1	2
2	Obtaining carton	7	4	4	8	8	8	8	3	3
3	Order completion	4	3	6	4	6	4	6	2	2
4	Packing order to carton	3	4	4	3	3	4	4	2	2
5	Placing carton to conveyor belt	6	7	7	9	9	9	9	3	3

L - left upper limb R - right upper limb

Table 2. Position: Carton Sealing
Tabela 2. Stanowisko zaklejania kartonów

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining the carton from the conveyor belt	6	7	7	9	9	10	10	3	3
2	Sealing the carton	6	4	7	7	9	8	10	3	3
3	Labeling the carton with delivery number	5	1	6	4	7	5	8	2	3
4	Returning the carton to the conveyor belt	6	7	7	9	9	10	10	3	3

L - left upper limb R - right upper limb

Table 3. Position: Package Sorting
Tabela 3. Stanowisko sortowania paczek

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining the package from the conveyor belt	6	7	7	9	9	10	10	3	3
2	Scanning the delivery number	3	2	6	3	5	4	6	2	2
3	Visual inspection of the delivery region	4	6	6	6	6	7	7	2	2
4	Loading the package to the appropriate pallet	8	8	8	10	10	11	11	4	4

L - left limb R - right upper limb

In the position of Order Carton Sealing (Table 2), four working positions were rated. Only when applying the postage label the left side of the body was exposed to a medium risk of MSD's, which qualified for AC 2. In other cases, the risk level was high - AC 3 - which requires correction of the position soon. In the case of obtaining the package for taping and applying the tape, the worker often lifted heavy packages, comprising of the ordered items. This required rapid large-range changes in position, significant tilting and twisting of the torso to one side, and a strong involvement of shoulders, elbows and wrists in the work. The largest load during the entire task appeared in the neck - bent forward at over 20° and twisted at the sealing of the carton; torso - due to the inclined posture of the worker in the upper extremities - in particular the arms (raised at the shoulder joint) and the wrist slightly deflected but also twisted.

In the position of Sorting Packages (Table 3) there were also four operator working positions. During the task the operator was exposed to different - often consecutive -

loads from medium AC 2 (when scanning the number of origin and conducting a visual inspection of the dispatch region), along with high AC 3 (while getting the packed, taped carton) to very high AC 4 (while placing the carton with the order to the appropriate pallet). During the task, the most vulnerable areas of the body were the trunk - leaning even more than 60° or twisted; the lower limbs - due to the standing nature of the work as well as the need for significant bending of the knees (over 60°) while putting cardboard on pallets; the upper limbs - particularly arms which are constantly raised.

The level of exposure of the left and right sides of the body can be considered as similar in the studied positions. Only in the position of the Order Picker, when retrieving the list of ordered products, was it noted that the right side of the body is subject to a higher load than the left, which is due to the fact that the employee obtains the list items with the right limb. The position of Carton Sealing exposes the upper right limb to a more vulnerable position than the left while applying the number, which results in different levels of exposure.

Considering the right side of the body allows the level of exposure to MSD's to be more correctly described. It was observed that of the entire 13 postures taken by employees at three job positions, none of them has a low or neglible risk of MSD's. Five postures were characterized by a medium level of exposure, AC 2 - hence ergonomic intervention may be required. In the case of seven activities, the level of exposure is high, AC 3 - corrective intervention is required soon. However, in one case, the risk was very high - AC 4 - immediate intervention is required.

The greatest workload appears in all positions when obtaining and depositing the carton with the order - this was a result of the high frequency of performance of these tasks (repetitive work), increased weight of the package, poorer ability to grasp the subject and the need for rapid large-range changes in position when removing and putting the carton on the conveyor belt. The risk of symptoms from the musculoskeletal system at the assessed positions primarily manifests itself within:

- trunk - significantly inclined, and in addition sometimes twisted to the side during all tasks performed by the employees for the majority of working time;
- lower limbs - associated with standing work on the assessed positions;
- arms - raised above 45° for a substantial proportion of working time - caused by the necessity of continuous lifting, carrying and depositing of cartons and their sealing, labeling and scanning;
- forearms - as in the case of the arms, the employee spends most of the working time performing tasks involving very heavy use of the upper limbs;
- wrists - though usually not too strongly bent, a majority of the work forces the worker to twist them.

CONCLUSIONS AND RECOMMENDATIONS

An important element in production systems, in addition to the physical components, is the human factor that affects performance, cost and quality (Istota inżynierii produkcji 2012). Improving the production system can not only cover the technical sphere, but also the realm associated with the environment and ergonomics. The aim of this study was to assess the level of exposure to MSD's in the process of order fulfillment using the REBA method.

Of all the respondents assessed, the following action categories were assigned:

- AC 2 - five activities,
- AC 3 - seven activities,
- AC 4 - one activity.

The main factors affecting the risk of a negative assessment of posture were:

- keeping the back bent and twisted;
- maintaining a significant deviation of the arms from the body;
- working in a standing position;
- the weight of the packaged carton.

Work at the assessed positions is associated with a significant risk of MSD's, therefore

corrective actions should be carried out soon. Ergonomic intervention should be related to:
- reorganization of workstations,
- redesign of working methods.

After making changes on the assessed position, re-evaluation with the REBA method is recommended to verify the effectiveness of the changes.

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ANALIZA OBCIĄŻENIA PAKOWACZY METODĄ REBA: STUDIUM PRZYPADKU

STRESZCZENIE. **Wstęp**: Jednym z elementów systemu logistycznego jest podsystem produkcji, który jest układem złożonym z elementów fizycznych takich jak: maszyny i urządzenia, narzędzia pracy, i (co najważniejsze) ludzi. Ponadto systemy zależne od człowieka-operatora są szczególnie podatne na problemy związane z: uciążliwościami, zapewnieniem produkcji, jakości i ze wzrostem kosztów szkolenia i nieobecności w pracy. Celem pracy była ocena obciążenia i ryzyka wystąpienia mięśniowo-szkieletowego dyskomfortu (MSDs) w procesie realizacji zamówień na stanowiskach pakowacza, analiza czynników ryzyka.

Metody: Do oceny zastosowano metodę Rapid Entire Body Assessment (REBA). Oceniono czynności związane z realizacją zamówienia na trzech stanowiskach.

Wyniki: Żadną z występujących czynności nie zakwalifikowano do AC 0 i AC 1; do AC 2 zakwalifikowano 5 czynności, AC 3 - 7 czynności, AC 4 - 1 czynność. Głównymi czynnikami ryzyka wpływającymi na negatywną ocenę pozycji podczas pracy były: utrzymywanie pleców pochylonych i skręconych, utrzymywanie ramienia odchylonych od tułowia, praca w pozycji stojącej, oraz ciężar zapakowanego kartonu.

Wnioski: Pakowacze pracujący na badanych stanowiskach w znacznym stopniu narażenie są na ryzyko MSDs, stąd działania korekcyjne powinny być przeprowadzone najszybciej jak to możliwe. Interwencja ergonomiczna powinna być związana z: przeprojektowaniem stanowisk oraz metod pracy. Po dokonaniu zmian na badanych stanowiskach zaleca się ponowną ocenę metodą REBA w celu weryfikacji skuteczności wprowadzonych zmian..

Słowa kluczowe: metoda REBA, obciążenie pracą, ergonomia, ryzyko, MSDs

ANALYSE DER BELASTUNG VON PACKERN MIT ANWENDUNG DER REBA-METHODE: EINE FALLSTUDIE

ZUSAMMENFASSUNG. Einleitung: Einer der Bestandteile eines Logistiksystems ist das Subsystem der Produktion, welches aus physischen Elementen besteht, wie: Maschinen und Geräte, Arbeitswerkzeuge, und (am wichtigsten) aus Menschen. Darüber hinaus sind die vom Menschen-Operateur abhängigen Systeme besonders anfällig für Probleme, die mit Beschwerlichkeiten, Sicherstellung der Produktion und Qualität sowie mit steigenden Schulungskosten und Abwesenheit in der Arbeit verbunden sind. Das Ziel der Arbeit war die Bewertung der Belastung und des Risikos von Muskel-Skelett-Krankheiten (MSDs) beim Prozess der Umsetzung von Bestellungen an den Arbeitsstellen der Packer, ferner die Analyse der Risikofaktoren.
Material und Methoden: Zur Bewertung dieser Faktoren wurde die Methode Rapid Entire Body Assessment (REBA) angewendet. Bewertet wurden Tätigkeiten bei der Umsetzung der Bestellungen an drei Arbeitsstellen.
Ergebnisse: Keine der Tätigkeiten wurde eingestuft als AC 0 und AC 1; als AC 2 wurden 5 Tätigkeiten eingestuft, AC 3 - 7 Tätigkeiten, AC 4 - 1 Tätigkeit. Die häufigsten Risikofaktoren, die die negative Bewertung der Haltung während der Arbeit beeinflussten, waren: gebeugter und gekrümmter Rücken, andauernde Entfernung der Arme vom Rumpf, Arbeit im Stehen und das Gewicht des gepackten Kartons.
Fazit: Die an den untersuchten Arbeitsstellen arbeitenden Packer sind weitgehend dem Risiko von Muskel-Skelett-Krankheiten ausgesetzt. Die ergonomische Intervention sollte die Umgestaltung der Arbeitsstellen und der Arbeitsmethoden umfassen. Nachdem die Veränderungen an den untersuchten Stellen vorgenommen worden sind, wird eine erneute Untersuchung nach REBA empfohlen, um die Effektivität der vorgenommenen Änderungen zu verifizieren.

Codewörter: REBA-Methode, Arbeitsbelastung, Ergonomie, Risiko, Muskel-Skelett-Krankheiten, MSDs.

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