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ANALYSIS OF PACKERS' WORKLOAD ON THE PACKING LINE – A CASE STUDY

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ABSTRACT. Background: One of the elements of the logistics system is the subsystem of production, which is a system composed of physical elements such as machinery and equipment, tools, and (most importantly) people. In addition, systems dependent on the human operator are particularly prone to problems related to: discomfort, ensuring production quality and increases in training costs and absenteeism.
Material and methods: The study was conducted in an establishment in the furniture industry, in the product packing department. The system under assessment included a position located at the conveyor belt. The aim of the study was to evaluate the load and the risk of musculoskeletal discomfort (MSD's) among workers and conduct an analysis of risk factors. For the evaluation method, the Ovako Working posture Analysing System (OWAS) was used. The evaluated activities related to the sequential packing of furniture in positions located at the conveyor belt.
Results: The result was 7 tasks qualifying for action category (AC) 1, 4 tasks for AC 2 and 5 activities for AC 4. The main risk factors influencing the negative assessment of posture were keeping the back sloped and twisted, work in a standing position and shifting weight onto one leg.
Conclusions and recommendations: On each of the evaluated positions where AC 4 occurred, employees back and legs were particularly vulnerable while retrieving elements. Corrective action in these positions should be carried out as soon as possible. Ergonomic intervention should be linked to: reorganizing positions with particular emphasis on retrieving items as well as the storage of packed products; introduction of employee rotation on such positions to ensure load variation of the musculoskeletal system. After making changes on the test positions, reassessment with the OWAS method is recommended in order to verify the effectiveness of the changes.

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

INTRODUCTION

One of the elements of the logistics system is the subsystem of production, in which the basic elements (resources) of each of the working process are: the people, the means of work and work items [Słowiński 2008]. In turn, production systems are defined as a complex system of physical elements such as machinery and equipment, tools and (most importantly) people. Employees in the manufacturing system are "internal consumers" and the system must be designed to meet their needs. At the same time, the production system 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 the human operator are particularly prone to problems related to: discomfort, ensuring production quality and increased training costs and absenteeism [Kasvi et al. 2000].

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Work performed by a person is accompanied by physical exertion, which can cause the appearance of musculoskeletal discomfort (MSD's) among employees [Vieira, Kumar 2004, Wang et al. 2014] in the form of health problems [Lasota 2001, Lasota 2008a, Lasota 2008b]. Studies have shown that the posture of the employee at work, range of motion, strength, repetition and duration must be taken into account when categorizing the level of physical activity [Kumar 1994]. The posture and movements of the employee during operation are important variables that must be taken into account in considering the safety of the work, as they are the two most important factors that determine the burden of the employee. The posture of the employee can be influenced by factors such as task accomplished, work, tools and their design and anthropometric characteristics [Vieira, Kumar 2004].

Research techniques proposed to estimate the level of discomfort and load profiles associated with employees taking different postures during labour can be divided into two groups - observational techniques and those based on devices. In the case of observation techniques, assessment of the angular deviation of body segments from the neutral position is achieved by means of visual observation. In contrast, techniques based on instruments involve continuous monitoring of posture performed by devices connected to the worker. Due to the lack of interference in the labour process, low cost and ease of use, observational techniques are more commonly used in industry [Genaidy et al. 1994].

Observational methods used to assess postural load of the employee include: Ovako Working posture Analysing System (OWAS) [Karhu et al. 1977], Rapid Upper Limb Assessment (RULA) [McAtamney, Corlett 1993], Rapid Entire Body Assessment (REBA) [Hignett, McAtamney 2000, Lasota 2006], Muscle Fatigue Assessment Method (MFA) [Rodges 1997] and Rapid Posture Evaluation (EPR - Evaluación Postural Rápida) [Guélaud et al. 1975]. It is important to note that they have been developed for different purposes and are therefore used under different workplace conditions [Kilbom 1994]. Each technique has its own operator classification system, which differs from other techniques; this may cause variance in the final result of the load of the operator, depending which technique was used.

Since the publication of scientific studies have shown its usefulness in assessing the posture of a worker while working in different environments such as warehouses [Torres, Vina 2012], construction [Li, Lee 1999], the poultry industry [Scott, Lambe 1996], operation and maintenance of boats [Joode et al. 1997], beverages distribution centres [Wright, Haslam 1999], metalworking [Gonzalez et al. 2003], wood [Jones, Kumar 2007], fish processing [Quansah 2005], the steel industry, electronics, automotive and chemical industries [Kee, Karwowski 2007, Lasota 2013, Lasota 2013b, Lasota, Ścigaj 2013, Lasota 2014, Muthukumar et al. 2014, Sesek et al. 2004, Wang et al. 2014], etc.

Modern production systems featuring assembly lines and packing lines are often equipped with a conveyor belt for transport. The performance of such a system is not determined solely by the technical subsystem, but also by the human subsystem. From an ergonomic point of view, a key element affecting workers and the efficiency of workflow is that of improper positions taken during work. In particular, this can be affected by excessive load. Discomfort in the human system can lead to problems associated with the provision of production, quality and an increase in costs related to sickness absence due to the negative impact of work on the health of workers. Hence, an essential element of ergonomic assessments is the detection of risks that require ergonomic intervention to improve the efficiency of the system.

This study focuses on one case relating to the packaging of furniture for positions located at the conveyor belt (Figure 1, Figure 2), which allowed for a detailed investigation on the interaction of employees with each element of the task. Due to the fact that employees perform the work manually, a set of methods was used including: interview, task analysis and OWAS, which is recognized as one of the simplest techniques of observation and in conjunction with the observation method enables fast performance evaluation and assessment of the level of ergonomic intervention associated with the risk of MSDs.

The aim of the study was to evaluate the workload and the risk of MSD's in the packaging of the product and the analysis of risk factors using the OWAS method.

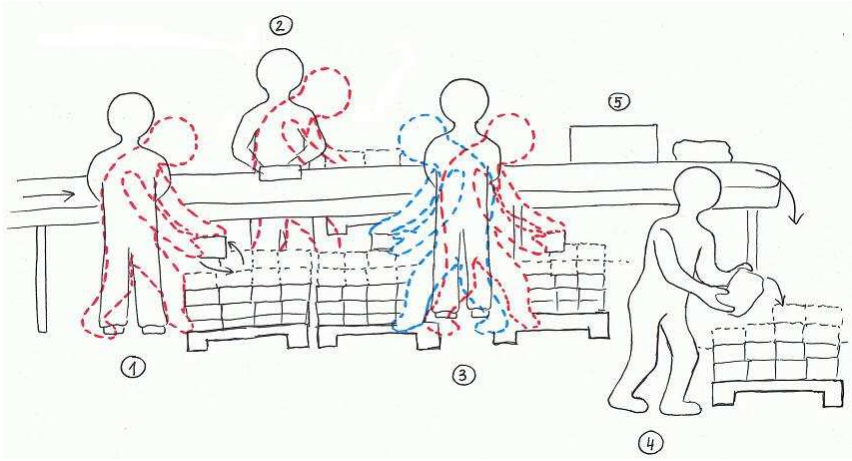

Fig. 1. The packing line - front view
Rys. 1. Linia pakowania - widok z przodu

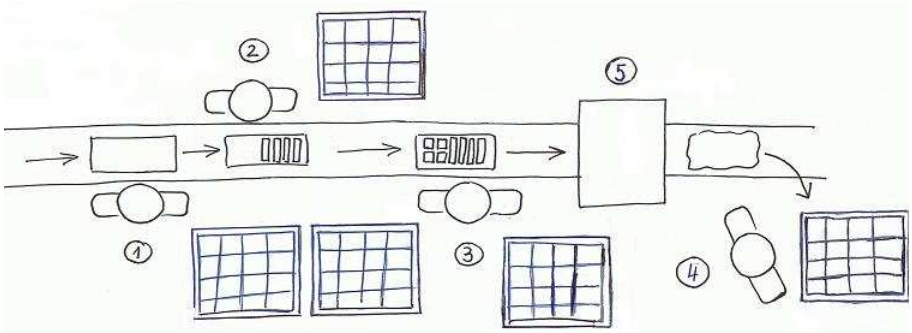

Fig. 2 The packing line - top view
Rys. 2. Linia pakowania - widok z góry

RESEARCH DESIGN AND METHODS

Research design

This case study was carried out in the packaging section of an enterprise in the furniture industry located in western Poland. The study was limited to the packaging of a table as a final product. The evaluated system consisted of 4 stations located at the conveyor belt. Work took place in a standing position, in three shifts with a working time of 8 hours per shift. The sample consisted of 12 men with a mean age of 28.5 years, standard deviation (SD = 4.5) and years of service 9.9 (4.6) years.

Process and Task Description

The work consisted of the sequential placement of individual elements of the furniture on the conveyor belt, according to the technological card developed by the technologist. The table packaging process was conducted in four stages in the following sequence: first the top was placed on the conveyor, followed by the legs, then fittings and boxes of screws. Once arranged, the elements enter a thermo-sealing machine whose function is to shrink wrap the furniture. The packaged product was then removed from the belt and laid on a pallet. Each employee on the packaging line was responsible for the

quality of component placement, controlled by the correct placement of its predecessor.

Data Collection

Several techniques have been used to collect data in this study: observation, interviews, task analysis and postural evaluation.

Observations, interviews and task analysis

Observations of the tasks carried out by employees were preceded by an interview with the manager and employees to understand the process of work and activities performed by employees. A hierarchical task analysis [Annett 2004] was used to identify the activities performed by the Packers. Four tasks were identified in the activities performed by employees (Table 1 - Table 4).

Table 1. OWAS rating for position no. 1 - setting down the tabletop
Tabela 1. Ocena OWAS na stanowisku nr 1 - umieszczanie blatu

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Obtaining	4	1	5	1	4
2	Visual inspection	1	1	2	1	1
3	Setting down	2	1	2	1	2

Table 2. OWAS rating for position no. 2 - laying down the legs
Tabela 2. Ocena OWAS na stanowisku nr 2 - układanie nóg

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Obtaining	4	1	5	1	4
2	Visual inspection	1	1	2	1	1
3	Setting down	2	1	2	1	2

Table 3. OWAS rating for position no. 3 - placement of fittings
Tabela 3. Ocena OWAS na stanowisku nr 3 - umieszczanie okuć

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Visual inspection	1	1	2	1	1
2	Obtaining fittings	4	1	5	1	4
3	Placing fittings	1	1	2	1	1
4	Obtaining box	4	1	5	1	4
5	Packing to box	1	1	2	1	1

Table 4. OWAS rating for position no. 4 - depositing to pallet
Tabela 4. Ocena OWAS na stanowisku nr 4 - odkładanie na paletę

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Visual inspection	2	1	2	1	2
2	Obtaining	2	1	3	1	2
3	Transfer	1	1	7	1	1
4	Depositing	4	1	5	1	4
5	Return	1	1	7	1	1

The OWAS Method and postural evaluation

The OWAS method was developed by Finnish authors in the Oy Ovako Company [Karhu et al. 1977] and has been disseminated in many countries. The method was developed to assess the risk of exposure to MSD's associated with the posture of the employee while working. The method comprehensively considers the issue, based on an observation technique whilst performing the work. The approach takes into account the posture taken by the operator during operation by highlighting the following body segments: the trunk (back), arms, legs, and measuring the

external load in kilograms, which has a significant impact on risk. The basis for the assessment of exposure to MSD's is the degree of the total load on the body with regard to posture and the external load. The OWAS method is focused on the identification of problems and corrective actions which finds its expression in terms of evaluation. The main objective of the assessment, therefore, is to make possible the disclosure and correction of undesirable operations.

In this method, the model distinguishes three segments of the human body, which may take different postures and external loads. The OWAS method takes into account the load derived from four factors:

- Back position (four coded items: 1 - straight/ upright, 2 - bent forward, 3 - straight and twisted, 4 - bent and twisted),
- Position of the arms (three codes : 1 - both arms below shoulder height, 2 - one arm above shoulder height, 3 - both arms above shoulder height),
- Position of the legs (seven items: 1 - sitting position, 2 - standing on both legs, knees straight, 3 - standing with one leg extended, knees straight, 4 - standing with two bent knees, 5 - standing on one bent knee, 6 - kneeling on one or both knees, 7 - walking or moving),
- External load in kg (three codes: 1 - less than 10kg, 2 - from 10 to 20kg, 3 - over 20kg).

The total load code for the operator is comprised of the codes for the position of the back, the position of the arms, legs and the position of the external load, thus creating a four-digit code. Their combination creates categories describing the assessment of the risk of exposure to MSD's and categories of actions (AC) necessary to improve the working conditions on the test bench. The authors singled out:

- AC 1 - No risk: Normal posture, with no particular adverse effect on the musculoskeletal system. Intervention is not required.
- AC 2 - Low risk: Working posture has a slight detrimental effect on the musculoskeletal system, there is a light load, immediate intervention is not required, but the ergonomic adjustment should be taken into account in future actions.
- AC 3 - Medium risk: Working posture has a significant detrimental effect on the musculoskeletal system; ergonomic intervention should be carried out as soon as possible.
- AC 4 - High risk: Working posture has a very high detrimental effect on the musculoskeletal system; ergonomic intervention is required immediately.

Positions taken by the operators were assessed during routine daily work. In turn, positions taken by each of the workers were evaluated several times. The most unfavourable positions taken by the Packers were taken into account.

RESULTS AND DISCUTION

In position no.1 (Table 1) in which the employee placed the table top on the belt, three worker postures were rated. In the case of collection of the tabletop, exposure to MSD's was very high; AC 4, which requires urgent ergonomic intervention. Such a high rating was associated with both tilting and twisting of the back, with the weight transferred onto one leg bent at the knee. In the case of the visual inspection stage, the risk was assessed as low, AC1, and does not require intervention. In contrast, placement of the tabletop on the conveyor belt was associated with medium risk, AC2 which may entails the need to make changes to the position. For the evaluated position, the most vulnerable segment of the body to injuries arising was the back, which was usually leaning forward and bent and twisted at the same time.

In position no. 2 (Table 2) - stacking of the legs - three tasks were distinguished. Obtaining the legs for the table from the palette was associated with a high risk of MSD's, AC 4, which requires immediate intervention. The employee obtains the items whilst turning and leaning back and moving the weight onto one leg, which was bent at the knee joint. During visual inspection, the posture of the worker was correct: no risk, AC1. In contrast, placing the legs on the table whilst on the conveyor

belt qualified for AC 2, medium risk, due to forward tilting of the trunk.

In position 3 (Table 3) the employee placed fittings. Five distinct worker postures were identified. Obtaining fittings and boxes with screws were associated with a high risk, AC4 - intervention required immediately. Incorrect posture was caused by twisting while leaning back and transfer of weight onto one leg, which was bent at the knee joint. The posture of the worker in the other three actions was correct: no risk, AC 1, which does not require an ergonomic intervention.

In position no. 4 (Table 4) five worker postures were evaluated. In the case of the action of depositing the packed piece on the pallet, exposure to MSD's was very high; AC 4, which requires immediately ergonomic intervention. This procedure was associated with tilting and twisting of the back while the weight was transferred onto one leg bent at the knee. In the case of two tasks: taking items from the conveyor belt and the visual inspection of the packaged product, the risk of MSD's was classified as medium; AC 2. In turn, the transfer of the packed product and returning for another packed product was characterized by minimal exposure to MSD's, AC 1 - intervention is not required. The most vulnerable segment of the body to injuries arising was the back, which was tilted forwards during the inspection of the packaged product, obtaining items from the conveyor belt and depositing them on the pallet located on the trough. An incorrect posture was also taken by the lower limbs while downloading the product and setting it down on a pallet.

When assessing the packaging process, which took place on the following positions located at the conveyor belt, only 7 of the 16 activities evaluated were found not to be associated with the risk of MSD's - AC 1. In contrast, four tasks were associated with medium risk, AC 2, which means that the positions need to be changed. The main reason was excessive forward tilting of the back. There were no activities qualifying for AC3. In contrast, 5 of the 16 activities were related to very high risk, AC 4, which requires immediate intervention. The AC 4 rated positions included 4 tasks for obtaining components and one concerning the depositing of the packed table onto the palette.

It was observed that in all activities, the load was below 10kg and employees maintained arms below the shoulders all the time. Incorrect posture was taken by the back and lower limbs. In the case of the back, incorrect posture was observed in 9 out of 16 cases. Workers backs were excessively tilted and / or twisted, especially when obtaining items from the pallet. In the case of the legs, incorrect posture was also noted in 6 cases: body weight was transferred onto one leg, either upright or bent at the knee. Incorrect leg posture affected retrieving items from the palette and placing the packaged product on the pallet.

The main cause of the irregularity of postures of employees is believed to lie in incorrect job planning. Packaged items were on pallets, in which the initial height of the working plane was about 1.3 m, but over time decreased to approximately 0.2m, causing the appearance of awkward postures. Positions were not equipped with any technical measures that would allow the adjustment of the height of the pallet. Furthermore, in positions 1, 2 and 3 pallets are located behind the worker, causing twisting of the torso and bending, especially significant in the case of obtaining items from the lower layers. Such placement of pallets was probably "more convenient" for an additional person whose task was to replenish empty space on the pallets with successive portions of the pack.

CONLUSIONS AND RECOMENDATIONS

An important element in production systems, apart from the physical elements, is the human factor. This factor significantly affects performance, cost and quality [Istota inżynierii produkcji 2012]. The improvement of manufacturing systems should 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 packing of a product using the OWAS method.

Of the 16 postures evaluated, the results were:
- AC 1 - 7 operations,
- AC 2 - 4 operations,
- AC 4 - 5 operations.

The main risk factors influencing the negative assessment of posture were:
- Maintaining a sloping and twisted back;
- Working in a standing position;
- Transfer of the body weight onto one leg.

Work on the test bench was associated with a significant exposure of workers to health problems, hence changes to the positions should be carried out. Production engineers and specialists in the field of health and safety should pay particular attention to the organization of the packaging process and in particular the deployment of individual components subject to packaging. Ergonomic intervention should be related to:
- Reorganization of positions, with particular emphasis on retrieve items as well as the storage of packaged products,
- The introduction of a system of rotation of employees in order to ensure the variability of the workload.

After making changes on the test bench reassessment with the OWAS method is recommended in order to verify the effectiveness of the changes.

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ANALIZA OBCIĄŻENIA PRACĄ PAKOWACZY PRACUJĄCYCH NA LINI POTOKOWEJ - 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.
Materiał i metody: Badanie przeprowadzono w zakładzie przemysłu meblarskiego na dziale pakowania wyrobów. W skład ocenianego systemu wchodziły stanowiska zlokalizowane przy taśmie transportującej. Celem pracy była ocena obciążenia i ryzyka wystąpienia zaburzeń mięśniowo-szkieletowych (MSDs) u pracowników, analiza czynników ryzyka. Do oceny zastosowano metodę Ovako Working posture Analysing System (OWAS). Oceniono czynności związane z sekwencyjnym pakowaniem mebla na stanowiskach zlokalizowanych przy taśmie transportującej.
Wyniki: Do kategorii działań (KD) 1 zakwalifikowano 7 czynności, KD 2 - 4 czynności, KD 4 - 5 czynność. Głównymi czynnikami ryzyka wpływającymi na negatywną ocenę pozycji podczas pracy były: utrzymywanie pleców pochylonych i skręconych, praca w pozycji stojącej, przenoszenie ciężaru ciała na jedną nogę.
Wnioski i rekomendacje: Na każdym z ocenianych stanowisk wystąpiła KD 4, szczególnie narażone były plecy i nogi pracowników podczas pobierania elementów stąd działania korekcyjne na stanowiskach powinny być przeprowadzone najszybciej jak to możliwe. Interwencja ergonomiczna powinna być związana z: przeorganizowaniem stanowisk ze szczególnym uwzględnieniem pobierania elementów jak również składowania zapakowanych wyrobów; wprowadzeniem systemu rotacji pracowników na stanowiskach w celu zapewnienia zmienności obciążenia układu mięśniowo-szkieletowego. Po dokonaniu zmian na badanym stanowisku zaleca się ponowną ocenę metodą OWAS w celu weryfikacji skuteczności wprowadzonych zmian.

Słowa kluczowe: OWAS, obciążenie pracą, ergonomia, ryzyko, MSDs.

ANALYSE DER ARBEITSBELASTUNG VON PACKERN AM FLIESSBAND - EINE FALLSTUDIE

ZUSAMMENFASSUNG. Einleitung: Einer der Bestandteile eines Logistiksystems ist das Subsystem der Produktion, welches aus physischen Elementen besteht, wie: Maschinen und Geräten, Arbeitswerkzeugen, und (was am wichtigsten erscheint) aus Menschen. Darüber hinaus sind die von menschlichem Operator abhängigen Systeme besonders anfällig für Probleme verbunden mit arbeitsmä?igen Beschwerlichkeiten, mit Sicherstellung der Produktion und Qualität sowie mit steigenden Schulungskosten und unterschiedlich bedingter Abwesenheit von Mitarbeitern am Arbeitsplatz.
Material und Methoden: Die Untersuchung wurde in der Verpackungsabteilung eines Möbelproduktionsbetriebs durchgeführt. Bestandteile des bewerteten Systems waren Arbeitsstellen am Fließband. Das Ziel der Untersuchung war die Prüfung der Belastung und des Risikos von Muskel-Skelett-Krankheiten (MSDs) bei den Mitarbeitern und die Analyse von Risikofaktoren. Zur Beurteilung wurde die OWAS-Methode (Ovako Working posture Analysing System) angewendet. Beurteilt wurden alle Tätigkeiten beim sequenziellen Verpacken von Möbelstücken am Förderband.
Ergebnisse: In der Maßnahmenklasse (KD) 1 wurden 7 Tätigkeiten, KD 2 - 4 Tätigkeiten, KD 4 - 5 Tätigkeiten ermittelt. Die Hauptrisikofaktoren, die die negative Bewertung der Körper-Haltung bei der Arbeit beeinflussten, waren: gebeugter und gekrümmter Rücken, Arbeit im Stehen, Übertragung der Körperlast auf ein Bein.

Schlussfolgerungen und Empfehlungen: An jeder Arbeitsstelle kam KD 4 vor, besonders gefährdet waren beim Entnehmen von einzelnen Elementen der Rücken und die Beine der Mitarbeiter. Daher sollten die Korrektionsmaßnahmen an den Arbeitsstellen schnellstmöglich vorgenommen werden. Die ergonomische Intervention sollte Folgendes umfassen: die Umgestaltung der Arbeitsstellen mit einer besonderen Berücksichtigung der Entnahme von Elementen sowie der Lagerung fertiger Erzeugnisse und Einführung eines Arbeitsstellenwechselsystems für die Mitarbeiter zur Variierung der Belastung des Muskel-Skelett-Systems. Nachdem Änderungen in den untersuchten Stellen vorgenommen worden sind, wird eine erneute Untersuchung nach der OWAS-Methode empfohlen, um die Effektivität der eingeführten Veränderungen zu verifizieren.

Codewörter: OWAS, Arbeitsbelastung, Ergonomie, Risiko, Muskel-Skelett-Krankheiten, MSDs

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