Z E S Z Y T Y   N A U K O W E   P O L I T E C H N I K I   P O Z N A Ń S K I E J
Nr 72 Organizacja i Zarządzanie 2017

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RESEARCH OPPORTUNITY: INCORPORATION OF HUMAN FACTORS IN ORDER PICKING SYSTEM MODELS

DOI: 10.21008/j.0239-9415.2017.072.04

A key priority of the European Union's employment strategy and Europe 2020 is to create more and better jobs in Europe, while improving their quality and ensuring better working conditions. In order picking "man-to-goods" workplaces automation still will not be rational in the near future. This is an example of a working environment where humans are still central actors and determine their effectiveness and efficiency. Order picking activities are labour-intensive and time-consuming. Researchers have developed models for planning order picking activities and increasing the efficiencies of such systems by suggesting different warehouse layouts, order picking routes or storage assignments. Developed models for planning order picking activities largely ignore workers' characteristics, or human factors, suggesting that they cannot be substantiated, which leads to only partially realistic results. To fill this obvious gap the authors are trying, with an interdisciplinary approach, to find ways to incorporate human factors into order picking models and improve working conditions in order picking processes with a literature review and survey on employees' perception of working conditions and health problems.

Keywords: order picking, man-to-goods, ergonomics, human factors, planning

1. INTRODUCTION

A key priority of the European Union's employment strategy and Europe 2020 is to create more and better jobs in Europe, while improving their quality and en-

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suring better working conditions (Eurofound, 2015). Future development is planned and financially supported on the assumption that improvement of working conditions can ensure a longer working life and more sustainable work and employment. It is frequently written that in order to achieve economic growth and job creation, the working conditions of all workers need to be improved through higher standards of occupational health, safety and well-being at work, as well as enhanced opportunities for skills development and employment prospects (Misztal, Butlewski, 2012). The mentioned changes will have positive effects on participation in the labour market and on company productivity. Consequently, changes will reduce the risk of absenteeism and healthcare costs and improve family and social life.

Order picking is the process of retrieving items from their storage locations in a warehouse to fulfil customers' orders (Grosse, Glock, Jaber, Neumann, 2015). Its activities are labour-intensive and time-consuming, and they account for more than 50% of warehouse operating costs (Frazelle, 2002; Tompkins, White, Bozer, Tanchoco, 2010). Order picking is the most expensive operation and it is directly linked to customer satisfaction. Any wrong pick would lead to an unhappy customer and additional costs. Grosse et al. (2015) summarise that De Koster, Le-Duc, and Roodbergen (2007) suggested that more than 80% of all orders processed by warehouses are picked manually, which has been confirmed in a recent study (Napolitano, 2012). The situation will not change much in the wellbeing of humans in the near future because humans are still more flexible than machines and able of logical reasoning in reacting to unexpected changes in the order picking process.

Order picking system performance largely depends on human characteristics, storage equipment design, forklifts' characteristics and the planning/scheduling process. In practice, human factors in internal logistics and manual material handling are receiving more attention. Several storage equipment and machines that make manual order picking tasks easier to perform by workers were introduced recently to mitigate repetitive tasks that may result in musculoskeletal disorders for workers, for example, ergonomic design of forklifts (Gajšek, Đukić, Opetuk, 2015). Musculoskeletal disorders are the most often reported causes for absence from work and account for over 52% of all work-related illnesses and more than 2% of the gross national product in the European Union (Schneider, Irastorza 2010), where low back disorders are the most costly of the musculoskeletal disorders (Marras, Davis, Kirking, Bertsche, 1999). For this reason, and in light of demographic changes and an increasing work lifetime, human factors issues at work have gained importance. This is paralleled by legal initiatives in many countries, which leads to an increase in regulations that enforce occupational safety in logistics (Grosse et al., 2015). However, the changes are very slow and employers are very conservative and insist that improved conditions of work cannot return financial contributions within a reasonable time.

One may assume that the high practical relevance of human factors in order picking has led to substantial academic research in this area. The literature on order picking, however, has focused mainly on design and control aspects, including layout design, storage assignment, routing, batching and different operating strategies (Chackelson, Errasti, Ciprés, Lahoz, 2013) and generally does not study how the human factor interacts with the order picking system. Perhaps this is because ergonomic conditions may be difficult to quantify (Rouwenhorst et al., 2000). Existing planning and optimization models provide an incomplete picture of real-world order picking, which affects the quality of the planning outcome. This indicates that there is a gap between the situations studied in the literature and the observed situation in practice, which suggests that there is a need to integrate human factors into planning models of order picking (Grosse et al., 2015). New planning procedures that consider human factors could be implemented into Warehouse Management or Enterprise Resource Planning systems, which could help to generate more realistic plans for order picking. Recently only Grosse et al. (2015) started to build a conceptual framework to facilitate such an integration. We did not notice any investigation of the impact of scheduling on order pickers. Scheduling should be differentiated from planning due to the fact that planning defines "What" and "How", while scheduling defines "When" and "Who". Answers to questions "How", "When" and "Who" directly relate to a person who later carries out a certain activity.

This paper contributes to the existing literature on order picking and presents a conceptual framework that explores how we could integrate the human factor into order picking planning and scheduling models. The focus of this study is on picker-to-part order picking systems that are characterized by being labour-intensive. First, we set the theoretical background and continue with obtaining information via survey about characteristics of order picker's work, focusing on their health problems, their understanding of ways to improve their working conditions and concerns of the employer for the health of employees.

2. THEORETICAL BACKGROUND

"Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Ergonomics helps harmonize things that interact with people in terms of people's needs, abilities and limitations." ("Definition" [IEA], 2016).

Although many researchers distinguish between the terms 'ergonomics' and 'human factors', in recent times there is an increasingly present opinion that the terms 'ergonomics' and 'human factors' can be used interchangeably. CIEHF ("What is ergonomics?" [CIEHF], 2016) notes that "'ergonomics' is often used in relation to the physical aspects of the environment, such as workstations and control panels, while 'human factors' is often used in relation to wider system in which people work. Researchers and practitioners generally use the term that fits most closely with the research, cultural-linguistic zone or the industry that they are discussing. In this paper, we decided to use the term human factor in relation to the order picking system because it fits most closely with the research on that area.

Gross and his colleagues (Gross et al. 2015) investigated the significance of the human factor and order picking. We assess their work as the most important for achieving synergistic effects due to the integration of separately developing theories. Their main findings were:

– humans are the primary actors in manual order picking;
– in order picking the most important design characteristics are warehouse layout, storage assignment, routing and batching, and work organization;
– the outcome of the order picking process is influenced by the design of the system and by the characteristics of the order picker performing the required tasks;
– human factor elements as interactions in a human–system relationship can be subdivided into physical aspects (e.g. posture), mental aspects (e.g. competency) and psychosocial aspects (e.g. motivation or stress), which all have a direct impact on order picking outcomes (time, quality and workers' occupational health and safety) (Neumann, Dul, 2010);
– in planning order picking processes, the combined effects of order picking design and the human factor have to be considered to achieve a good performance (Neumann, 2004);
– human worker characteristics have to be considered when planning production and operations management activities (Boudreau et al., 2003; Gino, Pisano, 2008; Neumann, Dul, 2010; Ryan et al., 2011; Neumann, Village, 2012);
– the collaboration amongst researchers from human factors and operational research has been minimal (Ryan et al., 2011);
– attention to the human factor in operations management research is rare (Dul, Neumann, 2009; Neumann, Dul, 2010);
– incorporating human factors into order picking planning models is lacking.

Gross et al. (2015) conceived their conceptual framework for incorporating the human factor into order picking based on the following definition: "the order picker process in a manual picker-to-part system can, briefly, be described as follows (De Koster, Le-Duc, Roodbergen, 2007): The order picker first receives information about an order on a (typically paper-based) pick list. The information specifies item identifications, the required amount to be picked, their locations and the sequence in which items should be picked. Next, the order picker moves to the storage locations, collects the required items and returns to the depot to drop-off the order. The collected items are then packed and shipped to (internal or external) customers. To fully utilise the capacity of an order picker, orders are often combined into batches, which are sorted after collection.

Order picking time as an outcome can be split according to the tasks performed as follows (Tompkins et al., 2010):

- set up time: the administrative time an order picker spends prior to the pick tour;
- travel time: the time an order picker spends in the warehouse travelling to, from and between the storage locations (aisles);
- search time: the time required by an order picker to identify the parts to be picked from the shelves of the warehouse.
- pick time: the time to collect parts from their storage locations, which includes documentation, verifying the correctness of a pick, interruptions and restocking.

To get an overview of the state of the human factor and order picking Gross et al. (2015) conducted a systematic literature search. A short summary of the search results is provided below:

- manual order picking tasks are repetitive, and repetitiveness causes workers to develop MSD over time, especially if the tasks involve postures that cause discomfort on the joints and backs of workers;
- warehouse operations represent a risk environment for occupational accidents;
- workers learn as they perform order picking tasks repetitively. Learning was found to reduce both time needed and errors made in order picking work;
- workers' motivation impacts the performance of an order picking system;
- the search of the literature identified only two papers, which incorporate human factors in the design or modelling of order picking systems. Petersen, Siu, and Heiser (2005) compared several established storage assignment strategies and proposed one utilising the concept of 'golden zone picking' to reduce pick time, where the 'golden zone' is the area between a picker's waist and shoulders. Grosse, Glock, and Jaber (2013) considered worker learning in an OP model and studied its effect on storage assignment decisions.

There are not many studies on how to incorporate human factors issues into order picking scheduling activities, which are part of set up time task. For example, Galka, Ulbrich, and Günthner (2008) used MTM (Methods-time measurement) for picking performance calculation, but with no human factors focus. Lee and others (2015) showed reduced time on the picking process by reducing the cognitive load of the worker. Lodree, Geiger, and Jiang (2009) discussed how to incorporate human factors issues into scheduling activities, but their work was not grounded on the order picking process. They showed that the scheduling research literature and human factors research literature represent two disjoint sets. Consequently, the research literature collectively lacks a unifying framework that defines appropriate exchanges between operations research methods and human factors engineering driven by scheduling applications whose purpose is to optimize human performance and well-being. A scheduling task defines "When" and "Who" and directly influences order pickers. According to the findings of previous studies, we suggest that the scheduling task is added to basic tasks of order picking time defined by Tompkins et al. (2010) (Tab. 1). Tompkins et al. (2010) defined tasks under the assumption that each order picker is allowed to schedule its own tasks. That assumption limits the possibility to introduce human factors into order picking. Software or a planner who is organisationally placed above a group of order pickers should do the scheduling.

According to the literature review and our knowledge of the situation in practice, which will be described in section three, we assume that today's order pickers mostly adapt to a design that forces them to work in a usually uncomfortable, stressful or even dangerous way. On the other hand, ergonomists and human factors specialists seek to understand how a product, workplace or system can be designed to suit the people who need to use it ("What is ergonomics" [IEA], 2016). Their efforts still largely bypass the order picking area. Today, most of the effort is invested in designing ergonomic storage equipment and devices. Researchers need to extend their research work to more soft areas like planning and scheduling to facilitate the work of order pickers. They need to understand and design for the variability represented in the population of order pickers, spanning such attributes as age, height, gender, strength, cognitive ability, prior experience, goals. An excellent basis for further research is the work of Tompkins et al. (2010).

Table 1. Supplemented examples of critical human factor aspects for each order picking task type (proceeding from Tompkins et al., 2010)

	OP tasks				
HF aspects	*Scheduling*	Set up	Travel	Search	Pick
Perceptual	• *perceive scheduling operations*	• perceive set-up operations	• perceive warehouse layout	• Read pick lists	• perceive pick operations and technical support
Mental	• *understand HF and order picking system* • *prepare pick list for order pickers*	• receive and sort pick lists • Process documents	• Understand and remember pick route	• Search and identify items • Remember item locations	• Decide how to grasp and transfer a given item correctly
Physical	• *set up workstation*	• Set up workstation	• Travel between depot and pick locations • Carry items • Pull/Push trolleys	• Neck flexion extension	• Stretch, bend, reach for items • Extract, grab, pick, put down items
Psychosocial	Motivation, stress, workload, boredom, work organisation, co-worker and supervisory support				

3. EMPIRICAL RESEARCH OF ORDER PICKERS' WORK

In addition to the review of key papers dealing with the introduction of the human factor in the field of order picking, we started to research characteristics of order pickers' work in different warehouses in practice. In particular, we consider it necessary to be familiar with their understanding of their work, fatigue, health problems and feelings. A participant in the process most commonly has a different perspective on events than an observer. For this purpose, we have prepared a questionnaire divided into six topic areas. Respondents were asked about demographics, characteristics of their work (subunits: characteristics of means of transport they use, type of used identification and communication equipment, ergonomics), the presence of health problems, perceived impact of different equipment characteristics on health, perceived impact of different equipment characteristics on productivity and perception of employer's health care for employees.

Questionnaires were compiled on the basis of:

- articles on order picking,
- articles on ergonomics,
- information from order picking forklift and trolley equipment manufacturers,
- information from manufacturers of electronic equipment to capture data during order picking,
- statistics on injuries in the logistics sector,
- recommendations for the prevention of occupational diseases.

The survey was conducted in January 2016 in Slovenia, in twelve companies that have volunteered to our call.

3.1. Methodology

Two academic experts and two industry experts were asked to review the questionnaire in order to ensure its clarity and relevance as a survey instrument. This input was used to develop the final questionnaire. The questionnaire, excluding the demographics section, consists of five questions. The answers were provided in the form of a five-point scale.

The survey was paper-based because we assume that order pickers are less familiar with web-based surveys and familiar with paper documentation. All the respondents were working as order pickers during the survey. We collected 132 completed surveys from 12 Slovenian logistics companies. On average, the survey questionnaires were completed by 73% of all employed order pickers. Twenty (15.15 %) of 132 completed surveys were not fully completed and were consequently excluded from further detailed analysis.

The processing of the data collected below was technically based on the advice and findings of Field (2005). Until now, we have only been performing base queries on collected data. A more detailed analysis is planned for the future when we will manage to increase the base of completed questionnaires. For this year, we plan to extend the study to other European countries.

After demographics, the first question concerns the characteristics of respondents' work. For this purpose, we have prepared several arguments, which were divided into three subsections: characteristics of means of transport they use, type of used identification and communication equipment, ergonomics. "Characteristics of means of transport they use" concerns eight basic types of means that can be used for transportation of goods during the order picking process and frequency of their use in the eyes of respondents. "Type of used identification and communication equipment" concerns four basic types of identification and communication equipment used during the order picking process and frequency of their use in the eyes of respondents. The "Ergonomics" section consists of five sub-questions asking about the frequency of harmful movements, known from ergonomics papers, for example lowering loads from a height above the respondent's shoulders and head.

The second question concerns the health problems due to order picking activities in the eyes of respondents. We prepared a list of nine health problems, which we have observed in the scientific literature and statistical reports, namely pain in the lower back, pain in the neck, pain in the shoulder, pain in hand muscles, pain in leg muscles, pain in wrists, decreased vision, swelling of the legs and mental fatigue. We asked respondents to mark the adequate frequency of listed problems.

In the third question, we investigate order pickers' perceptions about the impact of characteristics of order picking technology and equipment on the health of the respondent. For this purpose, we offer to respondents in decision-making three different ways of work and four types of equipment previously mentioned in the first question.

In the fourth question, we investigate order pickers' perceptions about the impact of characteristics of order picking technology and equipment on the productivity of the respondent. For this purpose, we offer to respondents in decision-making three different ways of work and four types of equipment, which are the same as in the third question. With the third and fourth question, we test if respondents have a different perception of certain technology or equipment's impact on health and productivity.

The sixth question concerns employer's health care for employees. We prepared six statements that describe possible employer's behaviour. Respondents are invited to mark their perception of employer's behaviour on a five-point scale from fully disagree to fully agree.

3.2. Results

Most of the 112 order pickers who fully completed the questionnaire are male (95.5%). Except six the rest are younger than 50 years (94.6 %). 72.3% are under the age of 40 years and 35.7% under the age of 30 years. The majority are between the ages of 30 and 40 (41 order pickers). The structure of education is independent of age. In all age groups, workers have mostly completed secondary education

(76 order pickers or 76.8%) and only a minority elementary (10.7%) or higher (12.5%) education. Almost a half of respondents (42.5%) work more than five years in the order picker position and only 21.4% of them work in this position less than one year. Among the 12 companies researched, one is small, four are medium and seven are large with more than 250 employees.

25 order pickers (24.8%) usually carry goods in their hands and do not use any means of transportation. 41 order pickers (40.6%) are mostly using an electric pallet truck with the possibility of driving on it. The use of more expensive and ergonomically more sophisticated forklifts is rare. Only 6 order pickers (6% of all respondents) use the forklift daily with the possibility of lifting the worker to the height of the first floor of the storage rack. 12 of them (11.9% of all respondents) use the forklift daily with the possibility to lift a pallet to the height of picking on the floor level and only 3 order pickers (3% of all respondents) use the order picker forklift (Fig. 1).

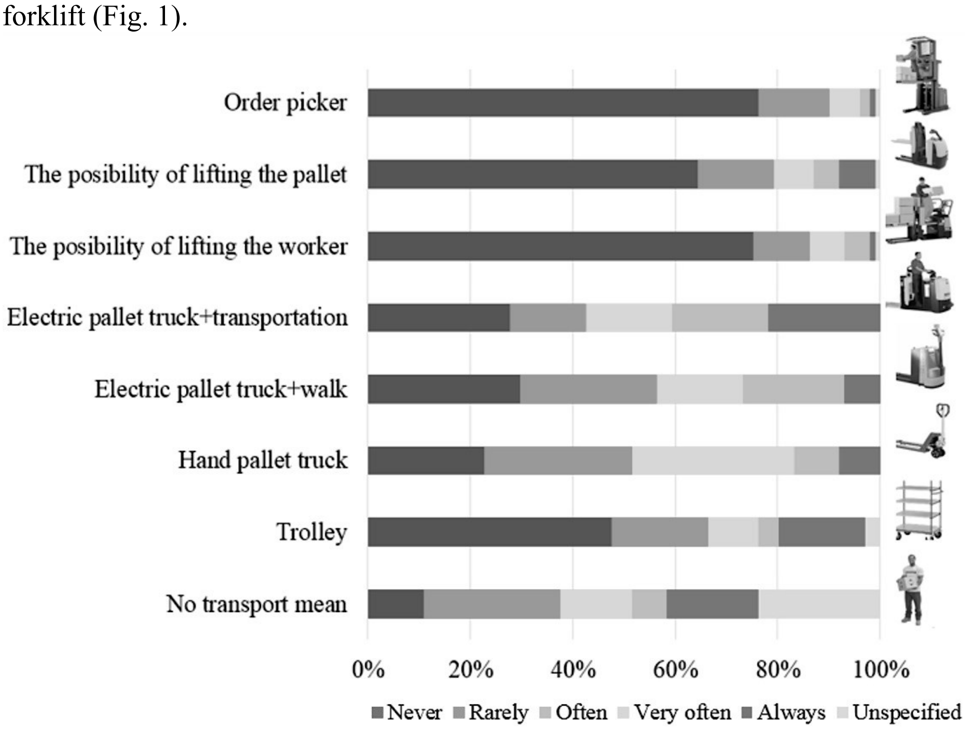

Fig. 2. Frequency of use of different means of transport for manual order picking

Depending on the frequency of use, order pickers most commonly use an electric pallet truck with the possibility of driving on it (40.6% of all respondents). This is followed by the use of electric pallet truck without the possibility of personal driving (26.7% of all respondents), carrying goods in hands (24.8% of all respondents) and using trolley (20.8% of all respondents). 72.3% of order pickers are walking between picking sites. 17.8% of order pickers work completely manually without using any means of transport, advanced and ergonomic solutions of forklifts are generally not present. Only 9 respondents (8% of all respondents) reported that they use only the forklift with the possibility of lifting the worker on the height of the first floor of the storage rack / forklift with possibility to lift pallet to the height of picking on the floor level / order picker forklift.

Order pickers most commonly identify goods and keep records of it based on barcodes/RFID. 64 order pickers (57.14% of all respondents) always use barcode/RFID terminal for order picking activities. This is followed by only paper work – 9 order pickers (8% of all respondents). Use of advanced technologies, which free the hands and reduce the need for decision-making is very rare. 83 order pickers (74.1% of all respondents) never use pick-by-voice technology and 80 (71.4% of all respondents) of them never use pick-to-light technology. Only 3 of them use pick-to-light and one pick-by-voice. Paper work is still present, but new technologies are probably “too expensive” to implement.

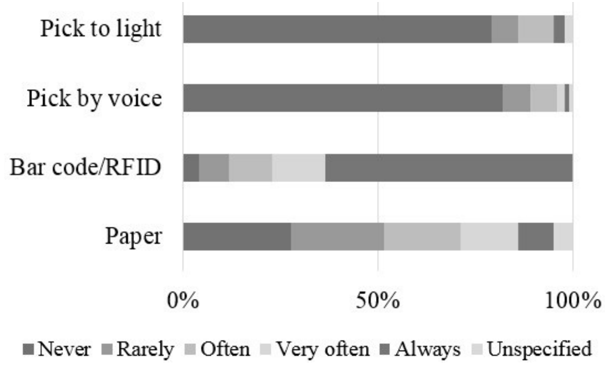

Fig. 2. Frequency of use of different information technologies for manual order picking

7.44% of order pickers never lower loads from heights above shoulder height and head but 10.43% of them do this all the time. From these, 60% of order pickers lower loads heavier than 20 kg and 40% loads between 10 and 20 kg. 56.38% of respondents lower heavier loads than 10 kg, 24.52% of these heavier than 20 kg. We noticed significant correlation between load lowering frequency and load weight ($\tau = -.510$, $p < .01$). Order pickers, who more frequently lower loads, lower heavier loads.

1.06% of order pickers never lift loads from height above knee-height but 22.34% of them do this all the time. From these, 52.38% of order pickers lift loads heavier than 20 kg, 38.09% loads between 10 and 20 kg and 9.52% loads lighter than 10 kg. 73.4% of respondents lift heavier loads than 10 kg, 31.88% of these heavier than 20 kg. We noticed significant correlation between load lowering frequency and load weight ($\tau = -.539$, $p < .01$). Order pickers, who more frequently lift loads, lift heavier loads.

In order picking activities, lifting loads occurs twice as often as lowering. Almost all order pickers have to lift loads. Loads heavier from 20 kg are more often lifted than lowered.

5.4% of respondents never walk between order picking spots but 30.63% of them do that all the time. 15.31% of respondents never step on a forklift but 39.63% of them do that very frequently. There is a significant correlation between frequency of walking between order picking spots and frequency of stepping on forklift ($\tau = .243$, $p < .01$). Frequency of stepping on a forklift is also significantly correlated with looking backwards during driving or working ($\tau = .414$, $p < .01$). 11.6% of respondents never look backwards during driving or working but 40.2% of them do it very often.

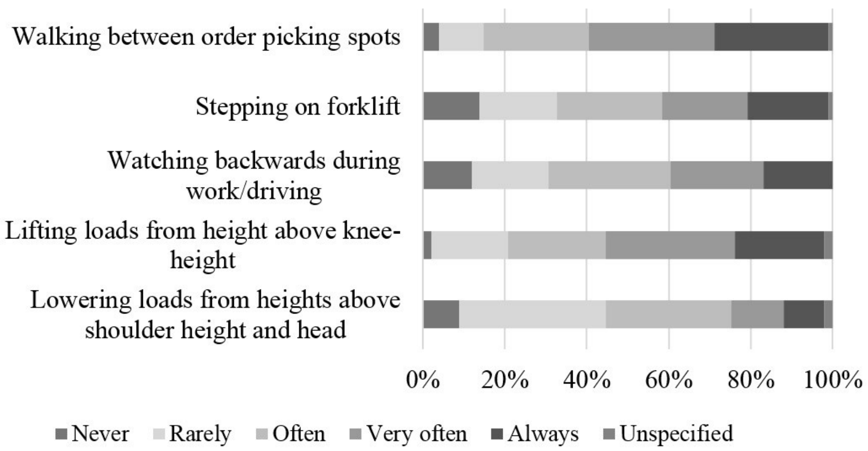

Fig. 3. Characteristics of order picking work

Order pickers associate some of their health problems with their work in the warehouse. Almost one third of them (31.5%) report permanent lower back pain. That is followed by neck pain (22.3%), pain in shoulders (20.5%), muscle pain in legs (19.6%), muscle pain in arms (18.8%), mental fatigue (17.9%), wrist pain (16.4%), swelling of the legs (13.4%) and decreased vision (10.7%). Lower back pain is significantly correlated with frequency of lowering loads from heights above shoulder height and head ($\tau = .295$, $p < .01$), frequency of lifting loads from height above knee-height ($\tau = .284$, $p < .01$) and frequency of walking between order picking spots ($\tau = .233$, $p < .01$). Neck pain is significantly correlated with frequency of lifting loads from height above knee-height ($\tau = .181$, $p < .05$), looking backwards during driving/work ($\tau = .133$, $p < .05$) and stepping on a forklift ($\tau = .149$, p < .05). Interestingly, mental fatigue is significantly correlated with frequency of stepping on a forklift (τ = .2, p = .005) and frequency of walking between order picking spots (τ = .231, p = .001).

Table 2. Correlations between health problems and characteristics of order picker's work

Health problem	Characteristics of order picker's work				
	Frequency of lowering loads	Frequency of lifting loads	Frequency of looking backwards	Frequency of stepping on a forklift	Frequency of walking
Pain in wrists	.340**	.218**			
Lower back pain	.295**	.284**			.233**
Neck pain	.248**	.181*	.133*	.149*	
Pain in shoulders	.295**	.262**			.303**
Muscle pain in arms	.300**	.237**			
Muscle pain in legs	.405**	.238**			.183*
Decreased vision	.148*	.184*			
Swelling od legs	.265**	.247**			
Mental fatigue	.125	.177*		.200**	.231**

** Correlation is significant at the 0.01 level (1-tailed)
* Correlation is significant at the 0.05 level (1-tailed)

Decreased vision is significantly correlated with a worker's age (τ = .258, p <. 01) and the amount of years working as an order picker (τ = .14, p < .05). Muscle pain in the arms is significantly correlated with a worker's age (τ = .15, p < .05).

On average order picker employees perceive:

– greater positive influence of a decrease in the quantity of lowering loads from heights above shoulder height and head on productivity (M = 3.26, SE = .117), than on health (M = 3.23, SE = .116), (t(207) = –.217, p > .05, small sized effect r = .01),
– greater positive influence of a decrease in the quantity of lifting loads from height above knee-height on health (M = 3.44, SE = .114), than on productivity (M = 3.25, SE = .108), (t(207) = 1.169, p > .05, small sized effect r = .08),
– greater positive influence of using an electric pallet truck with possibility of lifting the worker on the 1st level of the storage rack on productivity (M = 3.01,

SE = .112), than on health (M = 2.92, SE = .115), ($t(207) = –.591$, $p > .05$, small sized effect $r = .04$),

- greater positive influence of using an electric pallet truck with possibility of lifting pallet to the height of picking on the floor level on productivity (M = 3.26, SE = .124), than on health (M = 3.22, SE = .124), ($t(210) = –.213$, $p > .05$, small sized effect $r = .01$),
- greater positive influence of using an electric pallet truck with the possibility of driving on it on productivity (M = 3.5, SE = .122), than on health (M = 3.48, SE = .115), ($t(209) = –.139$, $p > .05$, small sized effect $r = .01$),
- greater positive influence of using barcode/RFID terminal on productivity (M = 3.75, SE = .122), than on health (M = 3.38, SE = .115), ($t(204) = –2.198$, $p > .05$, small sized effect $r = .15$),
- greater positive influence of using "goods-to-man" automatization on health (M = 3.75, SE = .112), than on productivity (M = 3.71, SE = .119), ($t(205) = .198$, p >. 05, small sized effect $r = .01$).

None of the above differences was significant. Employees almost do not distinguish the size of the positive impact on health and productivity in relation to different proposed technical and/or ergonomic improvements. The biggest positive impact on productivity is achieved with the usage of barcode/RFID terminals, and on health with "goods-to-man" automatization. On the other hand, the smallest positive impact on productivity and health is achieved with the usage of an electric pallet truck with the possibility of lifting the worker on the 1st level of the storage rack.

19.6% of order pickers may not suggest the type of means of transportation for their work to their employers, but 8% of them can. 27.3% of respondents do not feel the need to change the type of the most commonly used means of transportation, 28.6% of them is neutral on the issue and 40.2% of them feel the need to change the type of means of transportation. The need to change the type of most commonly used means of transportation is significantly correlated with workers who use hand pallet truck ($\tau = –.148$, $p < .05$) and electric pallet truck with the possibility of driving on it ($\tau = .189$, $p < .01$).

27.7% of respondents can decide how they will execute order picking tasks, but 10.7% of them cannot. The possibility to decide about the method of execution of the order picking task is significantly correlated with observed neck pain ($\tau = –.212$, $p < .01$), pain in shoulders ($\tau = –.147$, $p < .05$), muscle pain in legs ($\tau = .152$, $p < .05$), mental fatigue ($\tau = –.136$, p <. 05) and lower back pain ($\tau = –.261$, $p < .01$). We noticed low involvement of workers in designing their work environment. A question remains if they want to be involved at all.

24.1% of respondents report that employers do not educate them about ergonomics and health prevention, but 8.9% of them fully agree that their employers educate them. Education about ergonomics and health prevention significantly correlates with all proposed health problems except with wrist pain.

55.4% of respondents report that their employers do not organize a daily recreation program in their workplaces, but 4.5% of respondents have organized a daily recreation program. A daily organized recreation program is also significantly correlated with most of the proposed health problems. Employers do not strive much to educate employees about ergonomics and health prevention or to organize a daily recreation program for them. We believe, that many directors of logistics departments concur with the position of one of them, who in an interview stated:

– As director of logistics department I consider only what is written in legislation.
– Hard physical workers should not be informed about possible solutions to prevent health problems, because that will cause problems in every day processes.
– Humanisation of work is cost associated.
– Improved working conditions do not increase profit.

4. CONCLUSIONS

Some works remain physical, despite technological developments. One of them is the “man-to-goods” order picking process. Its activities are labour-intensive and time-consuming (account for more than 50% of warehouse operating costs). Causally, we would expect a lively researching of planning the order picking system and on the relations between all its elements. As humans are the primary actors in manual order picking, we would also expect many papers on how to adapt the rest of the system’s elements to workers and not the other way around.

Although the research community is familiar with the statement that in planning order picking processes the combined effects of order picking design and the human factor have to be considered to achieve a good performance, the science literature lacks papers on this subject. The reason for this situation can be disinterest, namely of logistics CEOs, who follow legalisation on work safety. Legislation is in most countries very loose and allows work, which is reflected in an above average absence from work and injuries. A well-balanced and harmonious workplace is in the case of order picking not always associated with the advantages of higher productivity and reduced risk of absenteeism from an employer’s viewpoint, or with a reduction in healthcare costs or other benefits from society’s viewpoint. Unfortunately, the benefits derived from safety training and practices are hard to directly quantify. Such short-sighted thinking can burn companies over the long haul.

Workers in order picking processes mostly adapt to order picking systems, which were planned solely based on productivity goals and less to prevent workers’ loss of health. Employees more or less perceive health problems and try to solve them through absenteeism or job replacement. They are mostly not able to take a part in the process of reorganizing the working environment to suit them. Although not a majority, some of the workers are interested in participating. Generally, they do not distinguish the impact of different equipment and methods of work on health and productivity. Here, there is clearly an opportunity for researchers. First, the employers do not see the impact of changes to improve working conditions on productivity, on the other hand, employees do not differentiate the effect on productivity from the effect on health. They generally believe that a specific equipment or method of work has the same effect on productivity and health. Researchers should try to find ways to adapt the order picking system to humans with the goal of a safe workplace, which will put companies in a position to be more profitable in a proven way.

5. DISCUSSION

According to the Industry 4.0 trend, we are on the verge of changing the role of the human in production systems. At the same time, every decision whether to automate the specified workstation is determined by economic calculations. Society is also facing changes due to the process of an ageing world population. An ageing population requires leading healthy lives and well-being at all ages, full and productive employment and decent work for all. The transport and logistics sector has historically experienced a fairly high rate of injury compared with other sectors. This will change quickly, and within one of the pillars of Industry 4.0 – Interoperability – there will be a need for new products and systems which will be compatible with the Internet of Things (IoT) or the Internet of People (IoP) approaches. Logistics and order picking systems will also need to absorb other trends like Circular economy, because there is a need for fast and accurate delivery systems, but within Socially Responsible Businesses.

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SZANSA BADAŃ: INKORPORACJA WYMAGAŃ ERGONOMII DO MODELI SYSTEMÓW KOMPLETACJI ZAMÓWIEŃ

Streszczenie

Kluczowym priorytetem strategii zatrudnieniowej Unii Europejskiej i programu Europa 2020 jest stworzenie w Europie większej liczby lepszych miejsc pracy, przy jednoczesnej poprawie ich jakości oraz zapewnieniu lepszych warunków pracy. W przypadku stanowisk komplementacji zamówień (człowiek operujący różnymi towarami) wdrażanie automatyki nadal nie będzie racjonalne w najbliższej przyszłości. Jest to przykład środowiska pracy, w którym ludzie nadal są głównymi wykonawcami pracy oraz determinują skuteczność i efektywność całego systemu. Prace na stanowiskach komplementacji zamówień są praco- i czasochłonne. Dotychczas badacze opracowywali modele planowania zbierania zamówionych dóbr oraz zwiększenia efektywności takich systemów, sugerując różne układy magazynów, trasy kompletacji zamówień lub przydział miejsc składowania. Opracowane modele komplementacji zamówień w dużej mierze ignorowały charakterystyki pracowników lub szerzej – zagadnienia ergonomii, sugerując, że nie mogą one być skonkretyzowane, co doprowadziło do tego, że za pomocą tych modeli uzyskano tylko częściowo realne rezultaty. W celu wypełnienia tej oczywistej luki autorzy próbują za pomocą interdyscyplinarnego podejścia znaleźć sposób na inkorporację ergonomii do modelowania procesów komplementacji zamówień. W tym celu, chcąc uzyskać poprawę warunków pracy i optymalizację stanowisk kompletacji zamówień, w artykule dokonano przeglądu literatury tematu i badań wśród pracowników odnośnie do ich percepcji warunków pracy i problemów zdrowotnych.

Słowa kluczowe: kompletacja zamówienia, prace manipulacyjne, ergonomia, *human factors*, planowanie