Ergonomic aspects and arduousness of work as a traditional warehouseman and the warehouseman supported by voice system: Comparative analysis

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Abstract: The article presents the ergonomic aspects of work storekeeper and warehouseman traditional voice-assisted system. The assessment of energy expenditure was developed while performing different activities related to work, which is important for ergonomics and also supports the work of the security services and occupational health in enterprises. The study underwent a warehouseman working in a traditional manner and assisted by warehouse voice system. With particular attention the workload for both positions was described.

A chronometric-tabular analysis by Lehmann has been carried out, allowing the assessment of energy expenditure at work. Assessment of energy expenditure was assessed by an estimation, so it was necessary to enumerate all activities of a warehouseman working in a traditional way and a warehouseman working with voice-assisted system. This was a two-stage assessment, in the first stage the body position was evaluated, which allowed to estimate energy expenditure serving to maintain this position. In the second stage, strain energy was assessed on the basis of work performed during work activities. The energy cost of operation was determined by adding the results obtained in both stages.

In the case of a clerk-assisted voice system warehouseman the energy expenditure was reduced by 115 kcal/min. Reduced energy expenditure positively contributes to the quality of work. 'The release of' hands of the employee and the possibility of a special kind of 'conversation' with the voice system involved in the process of picking goods allow for efficient operation.

Key words: warehouseman, warehouseman's work, warehouseman's work organization, voice-directed warehousing, warehouse ergonomics

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1. Introduction

Recently, the advancement of new technologies has a significant influence on creating systems that support human work. These systems are designed for the purpose of work facilitation and acceleration. In spite of the arising improvements, the number and volume of threats afflicting workers' health and life still remain at a high level.

Warehouses in the cotemporary economy play a crucial role. The surface and number of the newly built warehouse properties are constantly increasing. These changes lead to the growth of expectations regarding warehouses, which comprise of quick identification of the place where goods are stored, efficient internal means of transport, and the possibility of quick complementation of products. Changes in functioning and management of warehouses contribute to a great variety of tasks that are realized in such objects. Specialization and technological advancement, which has a significant influence on the way the warehouse processes are realized, as well as on the support in management, are also vital in warehouses' operation.

The characteristic feature of work performed by warehousemen is heavy physical load. It is connected with weight lifting and moving, repeated movements of hands and arms. These activities are the reason for inter alia back pain, spasms within muscle of the neck and upper extremities. The majority of musculoskeletal complaints are linked with cumulative work, which arises from long-lasting and repeated weight moving and lifting. These ailments may also be connected with traumata which are the result of accidents of warehousemen at work. Warehouse workers are also exposed to the risk of musculoskeletal complaints, since their work requires long standing or uncomfortable position and the significant part of their work is physically arduous and taking long hours.

The risk factors concerned with musculoskeletal load resulting from the type of performed work are directly linked with working process by worker's body position, exerted force and time cycles of the performed activities. The determinants occurring in working environment such as improper body position, body movements, exerting an excessive force considering time sequences can cause damages to muscle, strings and ligaments. (Roman-Liu, 2008). The proper and objective assessment of load or risk of musculoskeletal ailments requires considering all factors which can occur during the performed work.

2. Workload of the traditional warehouseman and the warehouseman supported by voice system

The assessment of energy expenditure while performing different activities connected with professional work is significant for ergonomics and work safety regulations in companies. In order to evaluate energy expenditure, learning the elements of work in the analyzed company's departments becomes indispensable. Therefore, the traditional warehouseman and the warehouseman supported by voice system are examined.

The work of warehouseman in a traditional way requires collecting the list of goods for order picking, changing clothes for work-wear, providing personal protection measures and a handcart, a forklift and a cart type BT, namely the warehouse cart. The type of cart depends on the type of warehouse which the warehouseman works in. His work is inseparably connected with the particular posture. The posture is the position of the body, arms and legs during the performed work. Uncomfortable or improper posture may occur during leaning, weight lifting or working in narrow passages (Górska, 1998). The work of warehouseman is strictly bound to using physical strength. It becomes indispensable during weight lifting, clenching hands on the cart's handle, closing the handclasp on the carried container, posi-

tioning of the container or item towards the body and additionally engaging sight, hands and forearms in reading orders and constant twisting of the body in order to lay aside the picking list.

The warehouseman has to devote the time and attention interchangeably to the list of goods and the performed task. The repeatability of these activities is particularly dangerous for the warehouseman as it engages the same parts of muscles and joints in a constant and recurring way. The work of the warehouseman supported by voice system differs from the work performed in a traditional way. Voice system allows for releasing warehouseman's hands from the constant verification of number and sort of the picked parcels. The warehouseman is equipped with earphones connected to audio terminal (Figure 1); he is hearing voice commands generated by the system and he is confirming vocally that the task is completed.

Figure 1. Audio terminal used for warehouse management

S o u r c e: http://www.voicesolutions.pl/terminal-glosowy-talkman-t5 [retrieved: 2014-03-01].

The information concerning parcel picking for the operator in the warehouse of the analyzed company is generated from the IT system on the portable terminal of bar coding display. Thanks to the voice system, the warehouseman has his hands and sight free, since using the terminal and confirming the performed operations take the form of voice response to the heard voice messages. This convenient solution becomes the most natural way of communication and information sharing.

Voice terminals have simple structure and they are convenient to use, for example when fastened to belt or harnessed. Voice terminals are equipped with four buttons: on/ off button, select button (sound volume, speed regulation, operator and task) and scroll button. Headphone sets with microphone are adjusted to working under intensive noise conditions and can be connected to voice terminals via the cable or wireless by using Bluetooth technology.

The picking list is received via radio from IT system and further processed by voice terminal for the warehouseman who is the operator of voice system. The worker of distribution warehouse picks the order when he hears in his earphones the instruction regarding product location and the quantity which should be collected. Performing these activities, he confirms them with voice commands and gives the actual quantity of collected goods until comple-

tion. The messages are pronounced by the warehouseman to the microphone which is connected to the earphone set and then processed by the terminal for system data. This becomes a 'dialogue' between a user and the voice control system. The work of the warehouseman supported by voice system is presented in Figure 2.

Figure 2. The warehouseman supported by voice system

S o u r c e: Materials provided by the analyzed company.

3. The chronometric-tabular method according to Lehmann and the assessment of energy expenditure in the warehouseman's work

One of the known and commonly used methods of analyzing energy expenditure during work is the chronometric-tabular method by Lehmann. It defines the volume of energy expenditure. Due to the simplicity of this method, it is frequently used for defining the arduousness of work on the particular position. The probable failures in assessment are scarce and possible to accept during empirically-based estimated method. In order to make the assessment, the following elements are analyzed (Jędruszczak and Romanowska-Słomka, 2011):

– energy expenditure of the particular activities,
– posture during work, the extent to which muscles are involved,
– degree of mono-typicality of muscles,
– degree and way of carrying and lifting weights.

The fundament of the proper assessment is making the list of working activities along with the time they take during a working day. This list is called the photography and timing of the working day. Timing should be conducted during days with the average intensification of work and it should entail activities that are typical of the particular working position. The photography of the working day assumes grouping activities into particular cycles. The basic and auxiliary activities should be registered regarding intervals at work during which the position of body is taken into consideration. The measurements have to be made several times in order to depict the average characteristics of the working day. The entire assessment of physical effort is comprised of (Janisz, 2011):

– assessment of energy expenditure,
– assessment of static effort,
– assessment of mono-typicality of movements.

Lehmann's method depends on the calculation of energy expenditure of the worker in the particular position basing on (Górska, 1998):

– time that particular activities are performed during the shift,
– unitary energy expenditure for performing different activities.

The assessment of energy expenditure will be made with estimated method. Therefore, it is necessary to distinguish all activities during work (Makowiec-Dąbrowska, Radwan-Włodarczyk, Koszada-Włodarczyk and Jóźwiak, 2000) of the traditional warehouseman and the warehouseman supported by voice system. This is a two-phase assessment. In the first phase, the position of body is considered, which allows for estimating energy expenditure concerning the posture. In the second stage, energy expenditure basing on the performed activities is assessed. The energy cost of the work performed is defined by adding the results received in both phases (Koradecka, 2008).

Table 1. Energy expenditure regarding the posture of the worker

Body posture	Energy input	
	kcal/min	kJ/min
Sitting	0.3	1.26
Kneeling	0.5	2.09
Squatting	0.5	2.09
Standing	0.6	2.52
Bowed standing	0.8	3.35
Walking	1.7–3.5	7.12–14.65
Walking with 10° gradient surface without load	0.7/1 m of height	3.14/1 m of height

Source: CIOP (2015). Obciążenie pracą – wydatek energetyczny. Instructional material [unpublished]. Warsaw, April 2015.

Estimating energy expenditure considering the involvement of muscles in particular working activities is an important element of this method (Table 2).

Table 2. Energy expenditure considering the involvement of muscles in particular working activities

Type and arduousness of work		Energy input	
		kcal/min	kJ/min
Finger, hand and forearm work	Light	0.3–0.6	1.3–2.5
	Average	0.6–0.9	2.5–3.8
	Hard	0.9–1.2	3.8–5.0
One arm work	Light	0.7–1.2	2.9–5.0
	Average	1.2–1.7	5.0–7.1
	Hard	1.7–2.2	7.1–9.2
Both arms work	Light	1.5–2.0	6.3–8.4
	Average	2.0–2.5	8.4–10.5
	Hard	2.5–3.0	10.5–12.6
Limbs and trunk work	Light	2.5–4.0	10.5–16.7
	Average	4.0–6.0	16.7–25.1
	Hard	6.0–8.5	25.1–35.6
	Very hard	8.5–11.5	35.6–48.1

Source: CIOP. (2015). Obciążenie pracą – wydatek energetyczny. Instructional material [unpublished]. Warsaw, April 2015.

The assessment of energy expenditure with Lehmann method assumes preparing timing of working along with energy expenditure. The results of the measurements of energy expenditure in the traditional warehouseman's work are given in Table 3.

Table 3. The results of the measurements of energy expenditure at the position of the traditional warehouseman

Timing			Energy input			
No.	Activity performed during working shift	t [min]	E_a [kJ/min]	E_b [kJ/min]	E_{a+b} [kJ/min]	E_c [kcal/min]
1	Loading on cart: – up to 5 kg	120	7.12	1.5	8.62	247
	– up to 10 kg	80	10.10	2.0	12.1	231
	– up to 20 kg	60	14.65	2.5	17.15	246
2	Document registering	40	2.52	0.4	2.92	28
3	Lack registering in warehouses	20	2.52	0.3	2.82	13
4	Cart-driving	40	2.52	2.5	5.02	48
5	Loading – up to 5 kg	120	7.12	1.5	8.62	247
	– up to 10 kg	80	10.1	2.0	12.1	231
	– up to 20 kg	40	14.65	2.5	17.15	164
6	Document management	90	2.52	0.9	3.42	74
7	Break	30	1.26	0.3	1.56	11

where:
t—duration of the activity,
E_a—energy expenditure regarding body posture during work,
E_b—energy expenditure regarding the group of muscles performing the activities,
E_{a+b}—energy expenditure regarding body posture during work and the group of muscles performing the activities,
E_c—energy expenditure for the given activity calculated as $E_c = E_{a+b} \cdot t$.

S o u r c e: Author's own elaboration.

Traditional warehouseman works in shift system with eight hours working time. The work as warehouseman is both the manual labour which comprises lifting and moving goods, packing on the pallets, or directly on the carts, and the brain work including listing of goods, reading orders, checking the status of the loaded goods with the orders, which requires collecting the documents constantly, registering and putting them aside. These activities are the source of the constant trunk twisting, fingers, hand and forearm work. The posture in the warehouseman's work includes walking, standing, standing position with elements of hand and fingers energy, hand and forearm work, bowed position engaging fingers. Energy expenditure of the traditional warehouseman is 1540 kcal/min. Energy expenditure at the level of 6446 kJ confirms that this work is qualified as hard.

The warehouseman supported by voice system performs the same working activities as the traditional warehouseman. However, the load he experiences is diminished by brain work and the activities connected with this. The decrease in energy expenditure occurs inter alia because there is no necessity to fill the listing and register warehouse flows. The load of energy expenditure regarding the traditional warehouseman and the warehouseman supported by voice system is depicted in Figure 3.

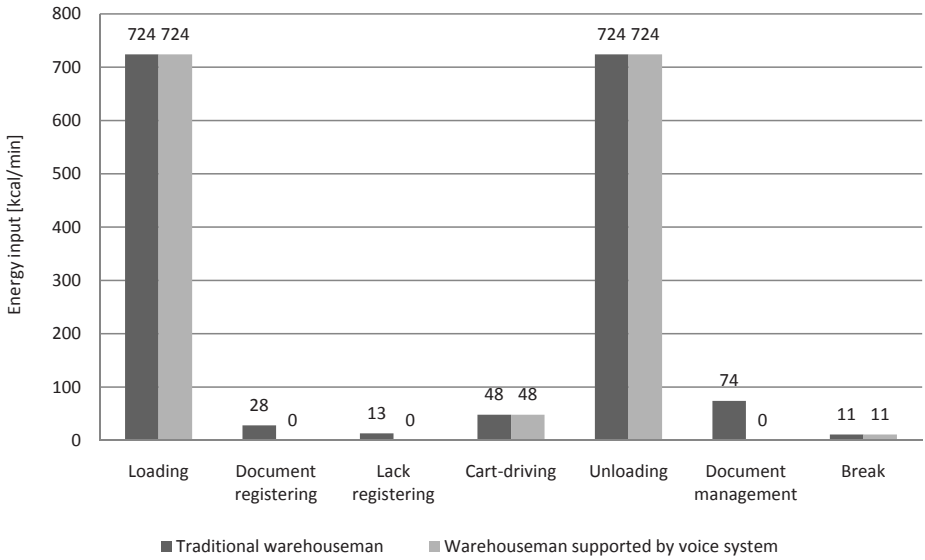

Figure 3. The comparison of energy expenditure regarding the traditional warehouseman and the warehouseman supported by voice system

S o u r c e: Author's own elaboration.

Energy expenditure of the warehouseman supported by voice system is decreased by 115 kcal/min. Lower energy expenditure has a positive impact on the quality of the warehouseman's work. When the warehouseman has his hands free and has the opportunity to 'speak' with voice system which accompanies the process of listing, his work becomes more effective.

4. Conclusions

The work as a warehouseman is connected with large physical load and monotype activities. The requirements that the traditional warehouseman meets are also concerned with a high level of repeatability of twisted trunk movements, keeping in mind large amount of data and registering the documents. The implemented facility in the shape of voice system that supports the work of a warehouseman diminishes the load of musculoskeletal system.

Energy expenditure regarding the work as the traditional warehouseman calculated with Lehmann's method amounts to 1540 kcal/min for working shift 720 min, which classifies the performed work as hard. The work is performed by a man, therefore the intensification of work is categorized as of average hardness.

The work of a warehouseman supported by voice system allows for decreasing volume and frequency of repeatability of twisted trunk movements connected with goods listing and documents completion. Energy expenditure is diminished then and the work becomes categorized as light or of average hardness.

On the basis of the research and assessment concerning the arduousness of physical effort for warehousemen of both types, it has been found that supporting work with voice system influences the efficiency of work and diminishes significantly energy expenditure during work. The reduction of trunk movements causes that physical load is decreased and the posture of the body during work is more diversified.

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Aspekty ergonomiczne oraz ocena uciążliwości pracy na stanowisku magazyniera tradycyjnego oraz magazyniera wspomaganego systemem głosowym – analiza porównawcza

Abstrakt: W artykule przedstawiono aspekty ergonomiczne pracy magazyniera tradycyjnego i magazyniera wspomaganego systemem głosowym. Opracowana została ocena wydatku energetycznego podczas wykonywania różnych czynności związanych z pracą zawodową, co ma duże znaczenie dla ergonomii, jak również wspiera działania służb bezpieczeństwa i higieny pracy w przedsiębiorstwach. Badaniu zostali poddani magazynier pracujący w sposób tradycyjny oraz magazynier wspomagany system głosowym. Ze szczególną uwagą opisane zostało obciążenie pracą dla obu stanowisk.

Przeprowadzona została analiza chronometryczno-tabelaryczna według Lehmanna, co pozwoliło na ocenę wydatku energetycznego w pracy. Ocena wydatku energetycznego została oceniona metodą szacunkową, a zatem konieczne było wyodrębnienie wszystkich czynności podczas pracy magazyniera pracującego w sposób tradycyjny oraz magazyniera wspomaganego systemem głosowym. Ocena ta jest dwuetapowa, w pierwszym etapie ocenie podlega pozycja ciała, co pozwala na szacowanie wydatku energetycznego służącego utrzymaniu tej pozycji. W drugim etapie ocenie poddawany jest wysiłek energetyczny na podstawie wykonywanych podczas pracy czynności roboczych. Koszt energetyczny pracy określa się poprzez zsumowanie wyników uzyskanych w obu etapach.

Wydatek energetyczny pracownika magazynu wspomaganego systemem głosowym zmniejsza się o 115 kcal/min. Mniejsze wydatkowanie energii pozytywnie wpływa na poziom jakości pracy. „Uwolnienie" rąk pracownika oraz możliwość szczególnego rodzaju „rozmowy" z systemem głosowym współuczestniczącym w procesie kompletacji towarów pozwala na efektywną pracę.

Słowa kluczowe: magazynier, praca magazyniera, organizacja pracy w magazynie, system głosowy w magazynie, ergonomia stanowiska pracy magazyniera