ASSESSMENT OF ERGONOMIC RISKS OF THE SELECTED WORK ACTIVITY BY NIOSH METHOD

Doc. Ing. Michaela Balážiková, PhD.[1]
Faculty of Mechanical Engineering – Technical University of Kosice, Department of Safety and Quality of Production, Slovak Republic[1]
michaela.balazikova@tuke.sk

Abstract: *Diseases of the support-motor system are the most common reason for work disability. They cause not only personal suffering and loss of income but also represent considerable costs for businesses and the national economies of individual countries. One of the important indicators of the incidence of serious health damage from work is the occurrence of reported diseases from professions and other work-related health damage. Even though the mentioned diseases have a rising tendency, it is possible to avoid them by assessment of work activities, introducing preventive measures and controlling the effectiveness of measures taken. The article presents an example of ergonomic risk assessment for working with loads as a means of prevention.*

Keywords: ERGONOMIC RISK, RISK ASSESSMENT, NIOSH

1. Introduction

"Ergonomy is an interdisciplinary science examining the mutual relationships of man and technology the work environment and monitoring the relationships within these subsystems with the aim of achieving a maximum degree of humanization and work safety, which a company and an individual can secure in a given stage of development" [1].

The aim of ergonomy is [1]:

- simplification of working conditions,
- to protect human health and to minimize the working of negative influences on a person during work activities,
- humanization of technology,
- designing of workplaces, instruments, machines, equipment, objects and aids such that it is possible to adjust their size and shape to the human body.

2. Ergonomic risk as a part of safety analyses

This is a tool which is intended for examining certain aspects working on a person in a working environment. The aim is identification of deficiencies at the given workplace and then an effort to remove them then using appropriate measures. The measures may be technological, systemic or organizational. These measures subsequently enable adaptation of working conditions and thus the optimizing of the work load.

Working with loads is considered to be any activity during which human strength is used for lifting, carrying, pressing, pulling and placing loads. We recognize both living and non-living loads. When lifting heavy loads, the risk of muscular-skeletal diseases occurring is increased. The most frequently burdened parts of the body are the knee joints and the lower part of the spine. The incorrect handling of loads can lead to great pain and serious illnesses [2].

3. The NIOSH Lifting index method

Unsuitable working positions, which can lead to illness of the motor apparatus, are frequently found during work activities having the character of physical work at work stations that are poorly organized ergonomically. New methods which are used today for assessing physical burden enable, with the help of postural analysis, the identification and overall assessment of risks leading to damage to muscles and the spine. The NIOSH Lifting index method belongs among those methods which are used for assessing ergonomic risks that arise when working with loads [3].

This is a European standard for assessing the limit for handling loads which have a weight greater than 5 kg and handling them for a period of 8 hours. The values are derived from dependence of the weight of the handled load and pressure on the intervertebral discs. Limit values relate to the pressure forces working at the transfer point of the lumbar and lower spine (between vertebrae L5 - S1) Fir. 1.

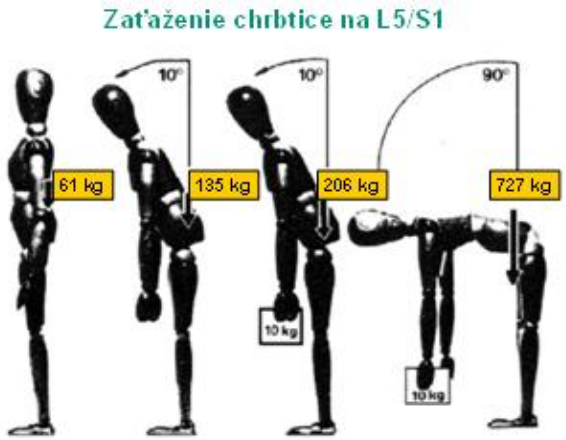

Fig. 1: *Loading of the spine between vertebrae L5/S1*

We can use the NIOSH method, which is focused on analysis of lifting actions, if the following are provided:

- balanced lifting, using both hands,
- smooth movements,
- good conditions for transferring forces,
- freedom of movement (without limitation of position),
- a suitable work environment.

The method for calculation of the weight limit cannot be used if the lifting or stacking of loads involves:

- use of an aid,
- an unsuitable working environments,
- lasts longer than 8 hours,
- working when seated or kneeling,
- unstable objects,
- simultaneous carrying, pressing or pulling [4].

The equation for calculation of the recommended weight limit (RWL) is based on a multiplier model, which gives the weight for each of the variables. The weighted shares are expressed as coefficients, which lower the load constant (LC). This load constant expresses the maximum weight of a load which can be lifted under favourable (ideal) conditions.

The weight limit which is recommended represents the maximum weight of a load for approx. 75% of the female population and up to 99% of the male population. Each healthy worker with a calculated value of weight can handle during a whole

work shift (8 hours) without increasing the risk of pain occurring in the lumbar part of the spine.

Likewise, the measure of relative physical ease, the so-called Load Index (LI), which is the ratio between the lifted weight and the RWL, is set as:

$$LI = (L\ [kg])/(RWL\ [kg]) \quad (1)$$

The recommended calculation of the NIOSH method is defined using the presented equation; explanations to the equation are in Tab. 1, in which a brief description of the individual multipliers is given, treated according to [15].

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \quad (2)$$

If the value of the Load Index (LI) is lower than 1.0, this indicates an inconsiderable risk of damaging health for the employee. If this value is equal to or higher than 1.0 this means high risk of damage to the spine, Tab. 2.

Table 1: *Multipliers of the Load Limit*

Multiplier name	Characteristics
LC Load Constant	Load Constant (LC = 23kg)
HM Horizontal Multiplier factor	The Horizontal Multiplier (H = 25/H) H – horizontal distance from the ankle to the centre of gravity of the load
VM Vertical Multiplier factor	The Vertical Multiplier (VM = 1 – 0.003 (V – 75)) V – depends on height of grasping the load
DM Distance Multiplier factor	The Distance Multiplier (DM = 0.83 + 4.5D) D – length of the lift in the vertical direction
AM Asymmetric Multiplier factor	The Asymmetric Multiplier (AM = 1 – 0.0032.A) A – depends on the angle of asymmetry when lifting the load
FM Frequency Multiplier factor	The Frequency Multiplier gives the number of lifting actions/1 min
CM Coupling Multiplier factor	The Coupling Multiplier describes the relation between the hands and the grasped load

Table 2: *Load Index LI*

LI < 1	LI > 1	LI > 3
Ideal case	Increased risk of pain in lower spine	Probability of an injured spine increases

During long-term work with loads it is also essential to devote attention to the calculation of the recommended load limit for employees. In this way it is possible to avoid damage to health, the occurrence of work injuries and work-related illnesses which are linked with expenditures on the side of the employer. The application of methods for assessing physical burden which are focused on reducing risks of damage to the locomotive apparatus can result in the easing of laborious work activities and thus also help protect employee health at work.

4. Assessment of ergonomic risk during selected activities using the NIOSH method

With the given work activity the handler lifts a plastic container full of metal components, which is stored in the lower part of the rack on roller tracks, Fig. 2 and 3. He lifts it with both hands, which he holds in front of the body, and puts in onto the transport wagon. The plastic container has an optimal configuration, with handles on both sides.

Fig.2: *Start of the action*

Fig.3: *Target position of the action*

Horizontal coefficient (H) - the position of the hands at the initial action is 40cm and the distance to the end action 28cm. This position is measured as the distance between the ankles and the centre of the load, Fig. 4.

Vertical coefficient (V) - the initial height of the lift (the lower part of the rack) is 39cm and the target height of the lift (the transport wagon) is 98cm. The vertical position depends on the height of grasping the load.

Distance coefficient (D) - the difference between the starting point and the target is 59 cm. The calculation is set by subtracting the length of the lift in a vertical direction (V) at the start of the lift from the length of the lift at the end of the action.

Asymmetrical coefficient (A) - is at the beginning by 10 degrees and at the intended place is zero. This depends on the angle of asymmetry when lifting the load.

Coefficient of coupling (C) - is defined as "good", describes the relationship between the hands and the held load.

Frequency coefficient (F) - lifting in this way are 2 lifts/minute for a period of 1-2 hours per day. This gives the number of lifting actions/1 min.

Load constant (L) - is the weight of the plastic container with the metal components; in the given case this is an average loading of 6kg and maximally with a number of lifts 12 kg.

These entered coefficients were assessed using the NIOSH - Excel method, see Tab. 3 and 4.

- H = 40 cm at the start of the action and 28 cm at the intended location
- V = 39 cm at the start and 98 cm at the intended location
- D = 59 cm
- A = 10° at the start and 0° at the intended location
- C = 1 (good – the plastic container has the optimal solution for handles)
- F = 2 lifts/minute
- L = 6 kg with average loading and 12 kg maximum loading
- Dur = 2 (activity lasts 1-2 hours daily at time of relaxation)

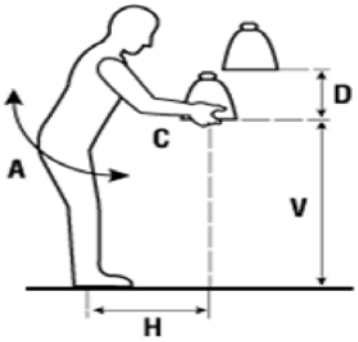

Fig.4: *NIOSH Lifting index*

***Table 3**: Calculation of loading of the support-motor system of a handler using the NIOSH method at the start of the action*

NIOSH Lifting Guidelines - METRIC

Job Title

Model Inputs:	Enter Data	Multipliers:		Model Outputs:	
Horizontal Location (H) (min 25, max 64)	40 cm (25 is best)	HM =	0.63	Recommended Weight Limit (RWL):	9.3 Kg
Vertical Location (V) (min 0, max 178)	39 cm (75 is best)	VM =	0.89	Lifting Index (LI = Load/RWL):	0.64
Travel Distance (D) (min 25, max 178)	59 cm (25 is best)	DM =	0.90		
Angle of Asymmetry (A) (min 0°, max 135°)	10 deg (0 is best)	AM =	0.97		
Coupling (1=good, 2=fair, 3=poor)	1 (1 is best)	CM =	1.00	Frequency Independent RWL:	11.1 Kg
Duration (Enter 1, 2 or 8 hrs. only)	2 hr(s) (1 is best)			Frequency Independent LI:	1.08
Frequency (min 0.2 lifts/min)	2 l/m (0.2 is best)	FM =	0.84	Recommendations:	Nominal Risk
Average Load Weight	6 kg				
Maximum Load Weight	12 kg				

Summary at the start of the action – the average weight (6 kg) is smaller than RWL (9.3kg) at the beginning of the action, and the maximum weight (12 kg) is greater than RWL and the FIRWL (11.1 kg). The LI is 0.64 and the FILI (1.08) is moderately over 1.0 which does not represent the total risk for the health of an employee and a small danger when lifting maximum load of 12 kg from the start.

Summary at the end of the action – the average weight (6 kg) is smaller than RWL (14.4 kg) at the target place. The maximum loading (12 kg) is smaller than RWL and FIRWL (17.1kg). LI is 0.42 and FILI is 0.70, which testifies to the small risk for the employee in the target place.

***Table 4**: Calculation of loading of the support-motor system of a handler using the NIOSH method in the target position of the action*

NIOSH Lifting Guidelines - METRIC

Job Title

Model Inputs:	Enter Data	Multipliers:		Model Outputs:	
Horizontal Location (H) (min 25, max 64)	28 cm (25 is best)	HM =	0.89	Recommended Weight Limit (RWL):	14.4 Kg
Vertical Location (V) (min 0, max 178)	98 cm (75 is best)	VM =	0.93	Lifting Index (LI = Load/RWL):	0.42
Travel Distance (D) (min 25, max 178)	59 cm (25 is best)	DM =	0.90		
Angle of Asymmetry (A) (min 0°, max 135°)	0 deg (0 is best)	AM =	1.00		
Coupling (1=good, 2=fair, 3=poor)	1 (1 is best)	CM =	1.00	Frequency Independent RWL:	17.1 Kg
Duration (Enter 1, 2 or 8 hrs. only)	2 hr(s) (1 is best)			Frequency Independent LI:	0.70
Frequency (min 0.2 lifts/min)	2 l/m (0.2 is best)	FM =	0.84	Recommendations:	Nominal Risk
Average Load Weight	6 kg				
Maximum Load Weight	12 kg				

5. Assessment of ergonomic risks with selected activities in the TECNOMATIX JACK software by the NIOSH method

5.1 Tecnomatix Jack

Tecnomatix is a product line of the company Siemens PLM Software, which includes several software tools for different areas of production that can be mutually connected. The tools in the Tecnomatix line enable industrial enterprises to use in practice the concept of a digital business, i.e. to plan and project production, design, verify and optimize processes and production resources in a digital environment, as well as to assess ergonomic risk.

This software package contains several modules focused on specific areas of design. One of them is also the module – Process Simulate Human – simulation and analysis of manual production operations from the viewpoint of feasibility, ergonomy and the loading of workers.

The measured coefficients were entered into the simulation in Tecnomatix, and after assessment by the NIOSH method in the module Process Simulate Human in the Tecnomatix software, the subsequent ergonomic risk of the selected activities was calculated, Fig. 5. The resulting values are in the "green numbers", which means that the given activity is safe for workers in terms of ergonomy.

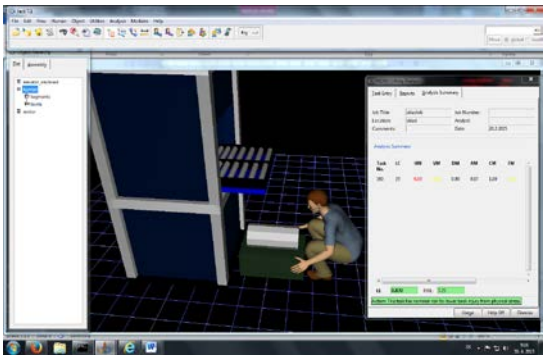

***Fig.5**: Assessment of simulation in the Tecnomatix software*

6. Comparison between the NIOSH – Excel method and NIOSH simulation in Tecnomatix

On the basis of the depicted values in NIOSH-Excel and the simulations in Tecnomatix, it is evident that there is only a small difference between them.

In the NIOSH-Excel table the resultant value of the load index is LI= 0.64 and the resultant value of the recommended weight limit is RWL= 9.3 kg, Tab. 8. These values are achieved after entering the measured coefficients into the table and with subsequent automatic calculation by the NIOSH Lifting index program. These same values for the coefficients were entered with the simulation in Tecnomatix. During the simulation it was possible to add physical dimensions, the sizes of the person, such as weight and height, which are important aspects with the assessment of ergonomic loading, which is also expressed in the result. The resultant value of the load index was LI = 0.830 and the resultant value of the recommended weight limit was RWL = 7.23kg.

Since the load index is in both cases under 1 (LI < 1), this means that the given work activity indicates marginal risk of damage to worker health. But it should not be underestimated, because with everyday handling with loads during these work activities, sooner or later, damage to worker health could occur. Therefore, it is necessary in the future to continuously monitor and evaluate whether the worker is experiencing any health complications and propose effective measures for limiting such injuries.

Proposed measures:

- To use mechanical lifting equipment when working with loads,
- to store heavier materials at such a height in the rack where it will be more natural for a worker and where he will not have to exert himself,
- the training of employees for correct handling of loads,
- an employee should be sufficiently informed so that he takes seriously any first symptoms of over-loading and does not ignore symptoms of muscle pain,
- information and instructions should be repeated at regular intervals,
- to perform a check of whether employees are observing the prescribed principles and processes.

People experience many consequences even into old age. It is therefore appropriate to also argue that even in youth one needs to think about old age.

7. Conclusion

An employer which does not exclude manual handling of loads is obligated to ensure that this handling is as safe as possible for employees, with the least amount of risk to health damage. In the interest of removing or reducing the effects of manual handling of loads on employee health, the employer is obligated before beginning such work:

a) to assess risk with each type of manual handling of loads,
b) to take relevant measures,
c) to ensure health oversight by which the health capabilities of employees for manual handling loads is assessed.

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"VEGA 1/0150/15 Development of methods of implementation and verification of integrated systems for safe machines, machine systems and industrial technologies".

8. Literature

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