# Physical and Mental Stress in Work Activities

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**Abstract**. Physical and mental stress are a part of each work activity and have, in some way, an impact on human organism. The impact, they have, can become evident either immediately or after a longer period time. In the paper the authors present results of a research which aim was to assess total physical load, caused by the muscular effort of upper and lower limbs, large muscle groups and local muscular effort, while working with burdens. To collect the necessary research data, the Holter analyzer was used on a research sample of two employees working with cleaning components in a production hall. Based on the achieved findings the author formulate conclusions, incorporation of which into the ergonomic and organizational measures can significantly reduce potential negative effects of the monitored stressors.

**Keywords**: physical stress, mental stress, local load, work with burdens, manual handling, ergonomic

## 1. Introduction

According to statistics of the National Health Information Center, a state-funded organization founded by the Ministry of Health of the Slovak Republic (http://www.nczisk.sk/en/Pages/default.aspx), upper limb diseases caused by long-term excessive and unilateral loading accounted for more than a half of the occupational diseases admitted. As regards the occupational diseases, mostly at risk were again workers aged between 50 to 59 years. At particular, in 2019 there were 347 newly diagnosed cases of occupational diseases and occupational poisonings (188 men and 159 women). Compared to the previous year, this was increase of 39 cases (1 man, 38 women). A long-term trend in the number of occupational diseases is presented in Figure 1.

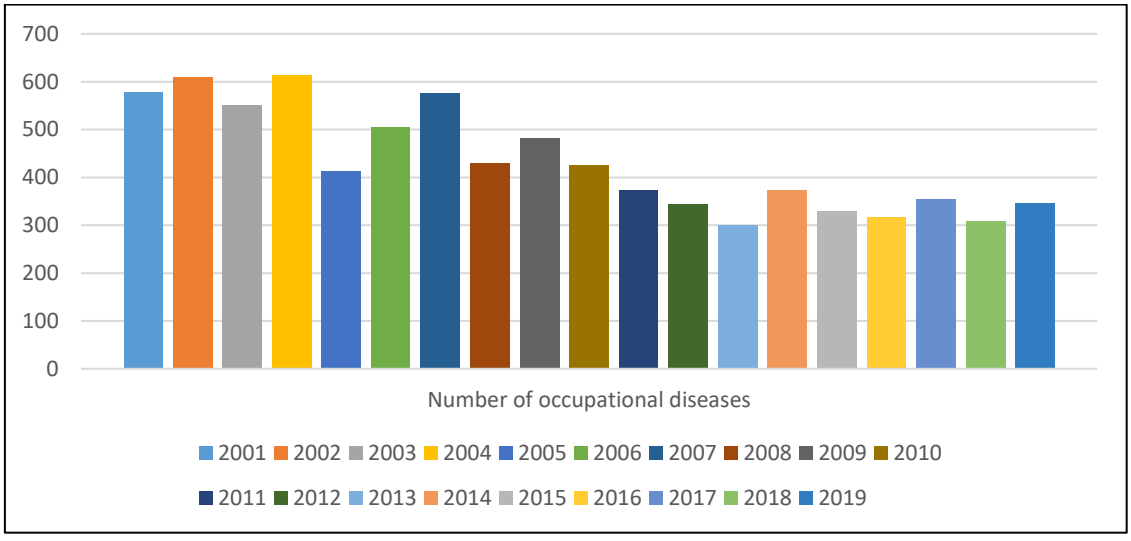


Figure 1: Development of the number of occupational diseases in the Slovak Republic from 2001 to 2019
Source: National Health Information Center

The most frequently reported occupational disease in 2019 was limb disease caused by a long-term, excessive, unilateral burden (181 employees, i.e. 52.2 % of all reported occupational diseases in the Slovak Republic). This was followed by diseases of bones, joints, muscles, blood vessels and limb nerves caused by working with vibrating instruments (62 employees, i.e. 17.9 %), infectious and parasitic diseases (42 employees, i.e. 12.1 %), hearing loss from noise (17 employees, i. e. 4.9 %) and skin diseases (12 employees, i.e. 3.5 %) [1].

Most occupational diseases have appeared in industry production, where people suffer mostly from pain in the upper limbs, as also infectious diseases. Mostly affected are workers aged between 50 - 59 year of old, with a slight increase in older age groups [2], [3].

## 2. Background of the issue

An individual worker's capacity to perform dynamic muscle work varies within very wide limits, and depends on his or her physical functional capacity, and particularly on cardiorespiratory capacity. Physical functional capacity in terms of cardiorespiratory (aerobic) capacity determined by maximal VO2, muscular performance (strength and endurance), and motor co-ordination (body control) is based on physiological mechanism: aerobic and anaerobic energy production, neuromuscular functions, and the regulation of body temperature. Anthropometric characteristics can be regarded as intervening factors in association with the output parameters of functional capacity. The utilization of different functional capacities is done by means of voluntary muscle contractions, which are impossible without an adequate level of motivation [4].

Effect of physical load on a human means to consider whether the physical activity during work (factors related to work facilities and workers` performance capacity) does not exceed physiological limits of workers and cannot induce health damage. While evaluating the worksite, it is necessary to focus on:

- space design and size of the worksite,
- used instruments and tools,
- working positions,
- manipulation with burdens and conditions for manipulation,
- position of controls,
- exerted force and frequency of use,
- total physical load,
- work and relax regime,
- shift rotation, etc. [5].

Space design and size of the worksite need to respect:

- anthropometric principles,
- physiological principles,
- psychophysiological principles,
- dimensions need to respect physiological dimension of the particular population, number of people on site, as well as security indicators, especially:
  - height of a manipulation plane,
  - space for lower limbs,
  - placement of controls and working tools respecting grasp distances and frequency of their use,
  - placement of working seats,
  - rationalization of working procedures, etc.

Working position depends on:

- character of performed work,
- dimensions and placement of a working site,
- quantity exerting a force to work,
- work intensity and precision.

Requirements for working movements are as follows:

- they must respect natural tracks and stereotypes (possibility of mutual adaptation, amplitude, force, speed, and rhythm),
- energy requirement must be proportional to the number and size of active muscle groups,
- to apply alternatively various muscle groups with a possibility to change to a working position with a small amount of static work,
- during activities requiring coordination of both limbs, the movements must be equally spread out on both limbs and their tracks must be analogical,
- if demands for the accuracy of movements increase, they must not be demanding for force exertion.

Physical work load means work load of motoric, cardiovascular and respiratory systems which is reflected in metabolism and thermoregulation. If there is a disproportion between the worker´s constitution and total muscular capacity and between the demand for physical fitness arising from the work tasks, the excessive straining of motoric apparatus appears [5], [6].

As to the muscular work there can be distinguished two forms:

- static muscular effort (isometric muscular contraction in which a tension increases) – more demanding,
- dynamic muscular effort (alternative application of muscular groups and alternation of the tension and release of muscles).

Assessment depends on the fact whether the work is executed by large muscles (representing more than 50 % of muscular mass) or by small muscular groups.

Manipulation with burdens means any rising, shifting, pulling, bearing, or moving burdens, with risk of health damage depending on various factors:

- characteristics of the burden (weight, storability, stability),
- required physical load (excessive weight, unsuitable working position),
- characteristics of working environment (insufficient manipulation space, micro-climatic environment),
- unsuitable regime of work and relax.

Local muscular stress is long-lasting, excessive and unilateral load on the same muscular groups, which leads to various diseases of bones, joints, muscles, tendons, ligaments, nerves, where the risk of health damage results from:

- intensive muscular force or multiple times repeated movements, especially in edge or unusual positions,
- other factors, such as the duration of force effect, spreading out of the used force in time, duration and organization of breaks, time for relaxation, etc., and
- the effect of other secondary factors, such as effect of vibrations, inconvenient micro-climatic conditions, bad conditions to grip the working tools, unsuitable personal working habits, insufficient training) [6], [7], [8].

## 3. Methodology of the research

Within the research, we carried out, assessment of physical load was done at the worksite for mending and cleaning of small metal components (electronic components) on the sample of two employees (women) working in the positions - cleaning components. The worksite in a production hall was naturally and artificially illuminated and naturally ventilated.

The basic working position was the sitting one with the possibility to alternate with a standing working position. Mostly small muscles of hands and forearms were exposed during work. The character of muscle work is static-dynamic with the dominance of a dynamic component. While working, the upper limbs of employees are bent in elbows in 90° angle.

During the cleaning of components, the worker can stand or sit on an adjustable seat. The worker cleans the components manually with cleaning agents. The used cleaning agents have Security Data Cards. After cleaning, the employee dries the component by compressed air. Two female employees who were selected for the assessment were 30-39 year old and they have performed the working operation for more than 5 years. Their body weight and body height were measured.

Measurement of *local muscular effort* was carried out by the Holter analyzer with the deviation of ± 3 %. For the assessment of testing results it was necessary to know the detailed time track of a working shift to calculate the time-weighted average whole-shift value of used muscle force. In the assessment the number of movements carried out during a working operation was taken into account, using video recordings of standard working operations to get accurate data.

Assessment of *total physical load* was based on whole shift measuring of heart frequency and determining the working energy output.

Assessment of *work with burdens* was carried out by direct observations, determining the weight of burdens, and by detailed analysis of photo-documents, video-recordings and working time tracks.

## 4. Research results

Basic micro-climatic conditions of a worksite were the following ones:

| | |
|---|---|
| $v_a$ (velocity of an air stream): | 0.01 – 0.015 m.s-1 |
| $r_h$ (relative humidity): | 32.0 % |
| $t_a$ (temperature): | 20.4 °C |

*Results of local muscular effort measurement*

Permissible values of local muscular effort are determined in relation to the muscle forces and frequency of working movements. The particular parameters for assessment of local muscular effort were the following: average whole-shift force output by extensors and flexors of upper limbs, average whole shift number of working movements of hands, and maximum number of working operations with force output more than 60 % $F_{max}$ at mostly dynamic work. Results of these measurements are presented in Table 1.

| Assessed parameter for upper limb | Limb | Employee 1 | Employee 2 |
|---|---|---|---|
| Average whole-shift output force of extensors | Right | 8.08 % $F_{max}$ | 11.25 % $F_{max}$ |
| | Left | 5.77 % $F_{max}$ | 10.14 % $F_{max}$ |
| Average whole-shift output force of flexors | Right | 6.25 % $F_{max}$ | 7.45 % $F_{max}$ |
| | Left | 7.01 % $F_{max}$ | 6.71 % $F_{max}$ |
| Average whole-shift number of working movements of hands | Right | 16870 | 18466 |
| | Left | 15979 | 17501 |
| Working operations with the used force over 60 % $F_{max}$ at dominantly dynamic work appeared up to* | | 2 x/shift | 35 x/shift |

Table 1: Results of assessment of relevant parameters of the local muscular effort

***Note:** The permissible number of working operations with the used force over 60 % $F_{max}$ at dominantly dynamic work is up to 600 x/shift.*

*Results of total physical load assessment*

Permissible values of physiological indicators of working load, energy output and heart frequency are determined by the Directive 542/2007 on health protection against physical load at work, psychic working load, and sensory load at work and they depend on sex and age of the employee. Measured and calculated results are presented in Table 2 [9], [10], [11].

| Assessed parameter | Units | Employee 1 | Employee 2 |
|---|---|---|---|
| Average whole-shift heart rate | (pules/min) | 93 | 81 |
| Increase of heart rate | (pules/min) | +11 | +11 |
| Average energy output/minute | ($kJ.min^{-1}$) | 4.62 | 4.62 |
| Average whole-shift energy output | (MJ) | 2.22 | 2.22 |
| Whole-shift permissible energy output of women in age of 30-39 years | (MJ) | 5.8 | |

Table 2: Heart rate and energy expenditure of the monitored employees

Assessment criteria of the whole-shift heart rate during work performed mostly by large muscle groups are presented in Table 3.

| Age category | Assessment criteria of the whole-shift heart rate during work performed mostly by large muscle groups | | | |
|---|---|---|---|---|
| | Absolute values | | Increase in heart rate over the starting value | |
| | A<br>Average values | B<br>Edge values | C<br>Average values | D<br>Edge values |
| 30 – 39 years | 106 | 115 | 29 | 32 |

Table 3: Values of whole-shift heart rate acc. to legislation regulations [13], [14]

*Burdens*

The weight of individual manipulated components did not exceed 5 kg. Only men are allowed to carry heavy burdens (over 15 kg). Measuring of work parameters related to manual manipulation with burdens did not show any exceeding of the given weight values.

## 5. Discussion

Measurement of local muscular effort did not prove any exceeding of average muscle forces in relation to the number of working movements per shift done by the assessed employees.

No exceeding of average muscle force in relation to the number of working movements per shift was determined for any of the assessed working operations. No exceeding of permissible values of energy outputs was proved for any of the assessed working operations. Assessment of work related to the manual handling of burdens did not show any exceeding of defined weight values.

In spite of these results (when all limit values are observed), it does not mean that the employer should be satisfied with the existing state. There are many ways how to improve working conditions of employees. Since majority of work at the assessed worksite was carried out in a sitting position, the next step should be assessment of ergonomic appropriateness of seats for employees, better organization of work, and continual education and motivation activities. The workload is also lowered by observing the principles of manipulation with materials and burdens, as well as by the introduction of the rotation of workers at worksites with different amount stress.

Pursuant to another legislation norm [14] the employer who did not rule out manual handling of burdens is obliged to ensure that the manipulation is as safe as possible for the employees, with the lowest level of the possible health risks. In order to get rid of or lower the effects of manual handling of burdens on employees` health, before its beginning the employer must

- assess the risk in the case of every kind of the manual handling of burdens,
- carry out respective measures, especially as regards physical strain, qualities of work environment, and requirements valid for the performed activity,
- ensure medical supervision, which is the assessment of health fitness of employees for the manual handling of burdens, taking into account individual risk factors and guide mass values.

A significant element in the operational system of OHS (Occupational Health and Safety) is the training and practicing of employees as regards appropriate handling of burdens as well as health hazards resulting from the inappropriate handling of burdens, which are usually documented in the Review of Hazards in Handling Burdens.

## 6. Conclusions

The measurements outcomes showed that as for the categorization of works regarding health hazards both assessed employees are proposed to be included into the works of the second category. The nature of muscle work was static dynamic, with the prevalence of the dynamic element.

Measurement of local muscular effort showed that work operations using force exceeding 60 % $F_{max}$ as regards predominantly dynamic work are permissible max. 600 times per a shift, which was observed (obtained employees data reached 2 times/shift and 35 times per shift).

Similarly, permissible values of energy output for the assessed workers were not exceeded, since for none of them the shift permissible value reached the limit of 5.8 MJ.

Assessment of the particular works from the aspect of the manual handling of burdens did not show any exceeding of guide mass values since the mass of handled burdens did not exceed 5 kg.

One of the important indicators of the occurrence of serious health damages resulting from work is the occurrence of the reported occupational diseases, professional intoxications, and other work health damages. The seriousness of the problem of the high proportion of the mentioned professional diseases affecting musculoskeletal, vascular, and nervous systems of employees exposed at work to an excessive strain of upper limbs is underlined by the fact that they are on the increase. Damages of musculoskeletal system are at the forefront also in work inability of working population; therefore it is necessary to pay close attention to the assessment of local muscular effort as well as overall muscular effort as measures preventing undesirable work health damages.

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