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Research article

IDENTIFYING HEALTH THREATS IN OCCUPATIONAL HEALTH RISK ASSESSMENT UPON EXPOSURE TO WORK HARDNESS CONSIDERING DETAILED ANALYSIS OF ITS SEPARATE COMPONENTS

P.Z. Shur[1], D.N. Lir[1,2], V.B. Alekseev[1], O.Yu. Ustinova[1], V.A. Fokin[1], E.V. Khrushcheva[1], N.V. Zaitseva[1]

[1]Federal Scientific Center for Medical and Preventive Health Risk Management Technologies, 82 Monastyrskaya Str., Perm, 614045, Russian Federation
[2]E.A. Vagner's Perm State Medical University, 26 Petropavlovskaya Str., Perm, 614990, Russian Federation

Hazard identification is an integral element of health risk assessment. Certain components of work hardness can be typical for specific occupations and this should be considered at the hazard identification stage.

In this study, we aimed to more precisely define approaches to hazard identification when assessing occupational health risks for workers under long-term exposure to work hardness involving detailed analysis of its components and likely adverse effects.

To develop more precise approaches (an algorithm) to hazard identification upon long-term exposure to work hardness and to test them, we performed detailed analysis of information in regulatory documents and research results reported in scientific publications. Certain components of work hardness were examined according to the Guide R 2.2.2006-05 and classified into seven groups of ergonomic indicators.

A suggestion was to consider not only occupational diseases (OD) as probable health outcomes within hazard identification but also work-related diseases (WRD) under exposure to work hardness, its specific components taken into account. More precisely defined approaches (an algorithm) to hazard identification upon long-term exposure to physical overloads involve analyzing presence of a relationship with health effects established for specific occupational groups typically exposed to certain components of work hardness; confirming biological plausibility of WRD considering pathogenetic pathways of their development; creating a hazard identification matrix with a list of likely health disorders. We visualized a list of OD and created a list of WRD, which are likely to develop upon exposure to certain components of work hardness. Use of these more precise definitions makes it possible to consider effects produced by components, which have not been established as regards OD development (body bending, physical displacement).

The suggested approaches were tested in hazard identification accomplished for such occupations as engine drivers, loaders and mechanics at various productions. As a result, it was established that diseases of the musculoskeletal system and connective tissue (M00–M99), nervous system (G00–G99), circulatory system (I00–I99), digestive system (K00–K93), genitourinary system (N00–N99), as well as diseases of the eye and adnexa (H00–H59) should be considered work-related diseases (WRD) whereas diseases of the skin and subcutaneous tissue (L00–L99) as well as endocrine diseases (E00–E90) did not belong to WRD. A hazard identification matrix was created by detailed analysis of the relationship between components of work hardness and likely health outcomes (per classes of diseases).

Use of the developed approaches ensures creating a proper theoretical base for hazard identification within occupational health risk assessment; allows minimizing uncertainties and unifying the assessment process due to detailed consideration of specific components. It can be recommended for supplementing the Guide on Assessing Occupational Health Risks for Workers.

Keywords: *hazard identification, work hardness, occupational risk, occupational diseases, work-related diseases, approaches to assessment, detailed analysis, likely effects.*

Pavel Z. Shur – Doctor of Medical Sciences, Chief Researcher-Academic Secretary (e-mail: shur@fcrisk.ru; tel.: +7 (342) 238-33-37; ORCID: https://orcid.org/0000-0001-5171-3105).

Darya N. Lir – Candidate of Medical Sciences, Leading Researcher – Head of the Health Risk Analysis Department; Associate Professor at the Department of Common Hygiene and Specialized Hygienic Disciplines (e-mail: lir@fcrisk.ru; tel.: +7 (342) 238-33-37; ORCID: https://orcid.org/0000-0002-7738-6832).

Vadim B. Alekseev – Doctor of Medical Sciences, director (e-mail: alekseev@fcrisk.ru; tel.: +7 (342) 236-32-70; ORCID: https://orcid.org/0000-0001-5850-7232).

Olga Yu. Ustinova – Doctor of Medical Sciences, Deputy Director responsible for Clinical Work (e-mail: ustinova@fcrisk.ru; tel.: +7 (342) 236-32-64; ORCID: https://orcid.org/0000-0002-9916-5491).

Vladimir A. Fokin – Candidate of Medical Sciences, Senior Researcher – the Head of the Laboratory of Occupational Risk Analysis of the Health Risk Analysis Department (e-mail: fokin@fcrisk.ru; tel.: +7 (342) 238-33-37; ORCID: https://orcid.org/0000-0002-0539-7006).

Ekaterina V. Khrushcheva – Senior Researcher – the Head of the Laboratory for Risk Management Methods and Technologies (e-mail: khrusheva@fcrisk.ru; tel.: +7 (342) 238-33-37; ORCID: https://orcid.org/0000-0003-2107-8993).

Nina V. Zaitseva – Academician of the Russian Academy of Sciences, Doctor of Medical Sciences, Professor, Scientific Director (e-mail: znv@fcrisk.ru; tel.: +7 (342) 237-25-34; ORCID: http://orcid.org/0000-0003-2356-1145).

Prevention of occupational diseases is among the priority trends that ensure achievement of the state strategic goals related to preservation of the population potential in the Russian Federation as an integral part of the national security[1,2]. Applied preventive measures aimed at preventing adverse effects such as both occupational diseases (OD) and work-related diseases (WRD) should be timely and well-grounded; this is largely determined by the system for assessing occupational risks (OR) implemented at industrial enterprises and economic entities[3]. An employer, following the guidelines by the Ministry of Labor and Social Support of the Russian Federation[4], can to his own discretion select a method to use in assessing levels of occupational health risks. Recommended and approved methods include the methodology for OR assessment accomplished in accordance with the Guide approved by the Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing[5].

At present, technologies aimed at implementing automation and robotization of industrial productions and using artificial intellect in various economic branches are developing quite actively. Despite that, work hardness remains a harmful occupational factor able to create occupational health risks for workers. The proportion of workers exposed to high physical loads has grown by 22 % since 2014 and reached 20 % of the total number of workers exposed to harmful and (or) hazardous working conditions in 2023. This makes work hardness a priority risk factor among other occupational ones[6]. The registered prevalence of OD caused by functional overstrain of organs and systems due to, among other things, heavy physical loads, is also growing (its growth rate is above 5 %); this pathology holds the second place in the total occupational morbidity (its proportion reaching 26.5 % in 2023)[7]. Loads, which are not compensated for by adequate recovery, can lead to a persistent decline in functional capabilities, overstrain and destructive-inflammatory processes. The latter manifest themselves not only as OD but as WRD as well[8]. The World Health Organization (WHO) estimates that diseases of the musculoskeletal system develop in 50–70 % of workers. About

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[1] O strategii natsional'noi bezopasnosti Rossiiskoi Federatsii: Ukaz Prezidenta RF ot 02.07.2021 g. № 400 [On the Strategy for National Security of the Russian Federation: the RF President Order issued on July 02, 2021 No. 400]. *GARANT: information and legal support*. Available at: https://base.garant.ru/401425792/ (April 23, 2025) (in Russian).

[2] O natsional'nykh tselyakh razvitiya Rossiiskoi Federatsii na period do 2030 goda i na perspektivu do 2036 goda: Ukaz Prezidenta RF ot 07.05.2024 g. № 309 [On national goals and strategic tasks of the Russian Federation development for the period up to 2030 and the future prospects up to 2036: the RF President Order issued on May 07, 2024 No. 309]. *Prezident Rossii: the RF President Official Web-site*. Available at: http://www.kremlin.ru/acts/bank/50542/page/1 (April 23, 2025) (in Russian).

[3] Trudovoi Kodeks Rossiiskoi Federatsii (ot 30.12.2001 g., s izm. 07.04.2025 g.) [The Labor Code of the Russian Federation (issued on December 30, 2001, last amended as of April 07, 2025)]. *GARANT: information and legal support*. Available at: https://base.garant.ru/12125268/ (April 23, 2025) (in Russian).

[4] Ob utverzhdenii Rekomendatsii po vyboru metodov otsenki urovnei professional'nykh riskov i po snizheniyu urovnei takikh riskov: Prikaz Mintruda i Sotszashchity RF ot 28.12.2021 g. № 926 [On Approval of the Guidelines on selecting the methods for assessing levels of occupational health risks and their mitigation: the Order by the Ministry of Labor and Social Support of the Russian Federation issued on December 28, 2021 No. 926]. *KODEKS: electronic fund for legal and reference documentation*. Available at: https://docs.cntd.ru/document/728029758 (April 23, 2025) (in Russian).

[5] Guide R 2.2.3969-23. Rukovodstvo po otsenke professional'nogo riska dlya zdorov'ya rabotnikov. Organizatsionno-metodicheskie osnovy, printsipy i kriterii otsenki; utv. Glavnym gosudarstvennym sanitarnym vrachom RF A.Yu. Popovoi 07.09.2023 g. [Assessment of Occupational Health Risk for Workers. Organization and Methodical Essentials, Principles and Assessment Criteria; approved by A.Yu. Popova, the RF Chief Sanitary Inspector on September 07, 2023]. *GARANT: information and legal support*. Available at: https://base.garant.ru/408890207/ (April 23, 2025) (in Russian).

[6] Rynok truda, zanyatost' i zarabotnaya plata. Usloviya truda [Labor market, employment and wages. Working conditions]. *Rosstat: Federal State Statistics Service*. Available at: https://rosstat.gov.ru/working_conditions (April 23, 2025) (in Russian).

[7] O sostoyanii sanitarno-epidemiologicheskogo blagopoluchiya naseleniya v Rossiiskoi Federatsii v 2023 godu: Gosudarstvennyi doklad [On sanitary-epidemiological welfare of the population in the Russian Federation in 2023: State Report]. *Federal Service for Surveillance over Consumer Rights Protection and Human Wellbeing*. Available at: https://rospn.gov.ru/documents/details.php?ELEMENT_ID=27779 (April 23, 2025) (in Russian).

[8] Professional'naya patologiya: natsional'noe rukovodstvo [Occupational pathology: national guide]. In: N.F. Izmerov ed. Moscow, GEOTAR-Media Publ., 2011, 784 p. (in Russian).

1.71 billion people suffer from musculoskeletal disorders globally including low back pains and neck pains, which can be related to work hardness[9] [1]. Bearing in mind high significance of work hardness as a risk factor and priority approaches to risk assessment, we can assume that there is a need in developing a methodology for assessing health risks for workers exposed to physical overloads. An initial stage in this assessment requires identifying potential responses of the body under exposure to the analyzed factor. At this hazard identification stage, attention should be paid to differences in various components of work hardness typical for different occupations.

The aim of this study was to more precisely define approaches to hazard identification when assessing occupational health risks for workers under long-term exposure to work hardness involving detailed analysis of its components and likely adverse effects.

Materials and methods. To develop more precise approaches (an algorithm) to hazard identification upon long-term exposure to work hardness and to test them, we performed detailed analysis of research results reported in scientific publications and information in regulatory and methodical documents.

Indicators describing work hardness were taken in conformity with the Guide R 2.2.2006-05 Hygienic Assessment of Factors Related to Working Environment and Work Process / Criteria and Classification of Working Conditions[10] and the Order issued by the Ministry of Labor No. 33n[11]. OD as adverse health effects were identified in conformity with the new Order issued by the Ministry of Health of the Russian Federation, which comes into force on September 01, 2025.[12]

A list of WRD caused by exposure to high physical loads (or specific components of work hardness) was created based on analyzing publications found in well-established Russian and international academic citation databases (eLibrary, CyberLeninka, PubMed/Medline etc.). They reported original research findings, provided systemic reviews or meta-analysis results. Publications were sought by using key words that described effects of work hardness on workers' health ('work hardness' and 'health effects' or "relationship between work hardness and health', or 'diseases related to work hardness'); they should be published in 2014 or later and a full text should be available in open access. Subsequently, publications were selected using the following basic criteria:

- they provided detailed description of working conditions per such a factor as 'work hardness' and / or its specific components;
- they provided data on functional disorders and / or health disorders;
- they reported findings that described the relationship between work hardness (its specific components) with functional disorders and / or health disorders;
- they provided such indicators as relative risk (*RR*) or odds ratio (*OR*) with 95 % confidence interval (95 % CI) and / or etiological fraction (EF) revealing the relationship between exposure to work hardness (including its specific components) and a negative health

[9] Musculoskeletal health. *WHO*, 2021. Available at: https://www.who.int/news-room/fact-sheets/detail/musculoskeletal-conditions (April 23, 2025).

[10] Guide R 2.2.2006-05. Guide on Hygienic Assessment of Factors of Working Environment and Work Load. Criteria and Classification of Working Conditions. *KODEKS: electronic fund for legal and reference documentation*. Available at: https://docs.cntd.ru/document/1200040973 (April 23, 2025) (in Russian).

[11] Ob utverzhdenii Metodiki provedeniya spetsial'noi otsenki uslovii truda, Klassifikatora vrednykh i (ili) opasnykh proizvodstvennykh faktorov, formy otcheta o provedenii spetsial'noi otsenki uslovii truda i instruktsii po ee zapolneniyu: Prikaz Ministerstva truda i sotsial'noi zashchity RF ot 24 yanvarya 2014 g. № 33n (s izm. i dop.) [On Approval of Procedure for conducting a special assessment of working conditions, Classifier of adverse and (or) hazardous production factors, reporting form on a specific assessment of working conditions and instructions how to fill it in: The Order issued by the RF Ministry for labor and Social Protection on January 24, 2014 No. 33n (with the latest amendments and supplements)]. *GARANT: information and legal support*. Available at: https://base.garant.ru/70583958/ (April 23, 2025) (in Russian).

[12] Ob utverzhdenii perechnya professional'nykh zabolevanii: Prikaz Minzdrava RF ot 18.04.2025 g. № 141n [On Approval of the list of occupational diseases: the Order by the RF Ministry of Health issued on April 18, 2025 No. 141n]. *GARANT: information and legal support*. Available at: https://www.garant.ru/hotlaw/federal/1810478/ (April 23, 2025) (in Russian).

response (or they provided enough data so that these indicators could be calculated).

Results and discussion. Effects that are considered OD can develop upon exposure to work hardness. Thus, the latest revision of the Order No. 141n contains the list of OD caused by heavy physical loads and functional overstrain of some organs and systems. It includes 27 diseases, namely, diseases of the musculoskeletal system and connective tissue (20 diseases), diseases of the nervous system (6 diseases), and diseases of the genitourinary system (1 disease) (Table 1). It is noteworthy that the OD list excludes two diseases of the musculoskeletal system and connective tissue and two diseases of the nervous system but

Table 1

Occupational diseases caused by work hardness taking into account its detailed components (The Order by the RF Ministry of Health dated April 18, 2025 No. 141n)

№	Likely diseases	1. Dynamic physical load, kg·m		2. Weight of cargo lifted and moved manually, kg		3. Stereotypical working movements, absolute		4. Static load, kg·sec		5. Working posture, % of time		6. Body bends, absolute	7. Physical displacement, km
		Regional	Total	Single	Permanent	Local	Regional	Regional	Total	Forced	Standing		
	Diseases of the musculoskeletal system and connective tissue (M00–M99)												
1	Chronic cervicobrachial syndrome – M53.1												
2	Low back pain – M54.5												
3	Cervical radiculopathy – M54.1												
4	Lumbar radiculopathy – M54.1												
5	Cervical myeloradiculopathy / Other specified dorsopathies – M53.8												
6	Lumbar myeloradiculopathy / Other specified dorsopathies – M53.8												
7	Chronic forearm myofibrosis / Other specified disorders of muscle – M62.8												
8	Rotator cuff syndrome – M75.1												
9	Bicipital tendinitis – M75.2												
10	Impingement syndrome of shoulder - M75.4												
11	Bursitis of shoulder – M75.5												
12	Bursitis of subacromial and / or subdeltoid synovial bursa / other shoulder lesions – M75.8												
13	Radial styloid tenosynovitis [de Quervain] – M65.4												
14	Medial epicondylitis –M77.0												
15	Lateral epicondylitis – M77.1												
16	Chronic tenosynovitis crepitans of hand and wrist (extensor muscle and thrum extensor muscle) – M70.0												
17	Elbow joint osteoarthrosis with dysfunction / other specified arthrosis – M19.8												
18	Knee joint osteoarthrosis with dysfunction / other specified arthrosis – M19.8												
19	Olecranon bursitis – M70.2												
20	Prepatellar bursitis – M70.4												
	Diseases of the nervous system (G00–G99)												
21	Polyneuropathy of upper extremities / other specified polyneuropathies - G62.8												
22	Carpal tunnel syndrome – G56.0												
23	Median nerve neuropathy (round pronator syndrome) / Other lesions of median nerve – G56.1												
24	Lesion of ulnar nerve – G56.2												
25	Lesion of radial nerve – G56.3												
26	Neuropathy of lateral popliteal nerve / Lesion of lateral popliteal nerve – G57.3												
	Diseases of the genitourinary system (N00–N99)												
27	Female genital prolapse – N81												

includes one new disease in this group as compared to the previous version. Some alterations were also made in detailed descriptions of the analyzed adverse factor; they specify separate indicators of physical load, which can cause development of relevant pathologies. This approach is well-grounded as evidenced by previous research works [2, 3], which describe its advantages for making more precise OR assessment and providing scientific grounds for planning preventive measures aimed at reducing OD risks, increasing work longevity and preserving work capacity.

The algorithm for more precise hazards identification upon long-term exposure to work hardness in assessing occupational health risks for certain occupations includes the following stages:

1. Analysis of available materials (research results reported in publications) about likely adverse effects occurring upon exposure to some components of work hardness in specific occupational groups.

The result of completing this stage is creating a list of likely adverse effects (diseases per relevant classes) upon exposure to some components of work hardness, which are classified into seven groups of ergonomic indicators in conformity with the Guide R 2.2.2006-05.

2. Analysis of materials that confirm development of adverse effects upon exposure to some components of work hardness considering their biological pathways.

The result achieved by completing this stage is a more accurate list of likely adverse effects considering pathogenetic pathways of their development upon exposure to some components of work hardness.

3. Selection of likely adverse effects allowing for detailed analysis of work hardness components based on using the hazard identification matrix.

Completion of this stage allows creating a hazard identification matrix containing a list of likely diseases (WRD per classes of diseases), which develop due to exposure to some components of too heavy physical loads in workers with specific occupations.

The suggested algorithm was tested within this study. Upon completion of the *first stage*, we established that some adverse health effects, which could probably be considered WRD, might develop in workers from the analyzed occupational group upon exposure to some components of work hardness. The 95 % CI > 1 or EF > 33 % for *RR* (or *OR*) were considered the criterion for considering a health effect a disease related to work hardness.

Operators employed at a rubber production were taken as an example occupational group. We found that work hardness associated with lifting and (one-time) moving a heavy cargo taking turns with other work (hazard class 3.1) and body bending (hazard class 3.2) determined a strong relationship with diseases of the musculoskeletal system (lower back pain) (*RR* = 2.2, EF = 55 %) [4]. Another analyzed occupational group was represented by operators employed at a bakery; they had to do stereotypical movements (up to 20,000 per a shift) with regional physical loads associated with predominant use of the arm and shoulder girdle muscles when tending to machinery and handling crude dough pieces (hazard class 3.2). As a result, they faced risks of diseases of the circulatory system (*RR* = 2.29; 95 % CI = 1.77–2.97; EF = 56.4 %; $p < 0{,}05$) and diseases of the eye and adnexa (*RR* = 2.2; 95 % CI = 1.66–2.92; EF = 54.6 %; $p < 0.05$) with high occupational causation; as well as diseases of the musculoskeletal system and connective tissue (*RR* = 1.66; 95 % CI = 1.24–2.24; EF = 39.9 %; $p < 0.05$), diseases of the genitourinary system (*RR* = 1.91; 95 % CI = 1.59–2.31; EF = 47.8 %; $p < 0.05$), and diseases of the digestive system (RR = 1.95; 95 % CI = 1.58–2.42; EF = 48.7 %; $p < 0.05$) with medium occupational causation [5].

Work tasks performed by repairmen at synthetic isoprene rubber production involve long periods spent in a forced working posture and periodical lifting and moving a cargo weighing more than 35 kg (hazard class 3.2). High prevalence of vertebral damage depending on working conditions makes it possible to consider then occupational (*RR* = 49.5;

$p < 0.05$) [6]. Mechanics responsible for repairing processing stations at oil production (primary oil processing) also have to maintain uncomfortable (up to 35 % of a work shift) and / or forced working posture (up to 10 % of a work shift) for a long time; in addition, they cover a distance up to 8 km to control how stations operate and to assess their state (hazard classes 3.1–3.2). This is likely to cause back pains (*RR* = 206; 95 % CI = 1.29–3.29; EF = 52 %; $p < 0.05$). In addition, an association was established with obesity risk (*RR* = 2.14; 95 % CI = 1.26–3.64; EF = 53 %; $p < 0.05$) [7].

Work tasks typical for such occupations as loaders involve high dynamic physical loads with lifting and moving boxes weighing up to 9 kg; the total weight of handled cargos is 1100–1500 kg; static loads involving the body and leg muscles can reach 200,000 kg·sec; more than 25 % of a work shift is spent in a forced working posture; they make more than 440 body bends over a work shift (hazard class 3.2). All this determines high risks of developing lumbosacral dorsopathy, facioscapulohumeral periarthritis, back pain, hand arthrosis and periarthrosis, myositis (*RR* = 2.22; 95 % CI = 1.21–4.08; EF = 55.1 %; $p < 0.05$) [8]. A weight of handled cargo above 10 kg for women and 15 kg for men is a risk factor of lumbago (*OR* = 1.46; 95 % CI = 1.18–1.82 and *OR* = 1.54; 95 % CI = 1.25–1.90 respectively) [9]. Progressing low back pains are also associated with manual handling of cargos weighing more than 30 kg (*OR* = 1.75; 95 % CI = 1.11–2.77) or 40 kg when handling rolling weights (*OR* = 3.93; 95 % CI = 1.81–8.52) [10].

In addition, lifting objects ≥11 kg is associated with an increased odds ratio of miscarriage (odds ratio, 1.31; 95 % CI = 1.08–1.58), and preeclampsia (odds ratio, 1.35; 95 % CI = 1.07–1.71) for pregnant women. Lifting objects for a combined weight of ≥100 kg per day is associated with increased odds of preterm delivery (odds ratio, 1.31; 95 % CI = 1.11–1.56) and having a low birthweight neonate (odds ratio, 2.08; 95 % CI = 1.06–4.11). Work involving body bending for not less than 1 hour per day is more likely to cause spontaneous abortions (*OR* = 3.2; 95 % CI = 1.3–9.8) and preeclampsia (*OR* = 1.5; 95 % CI = 1.09–2.08) than lifting heavy weights. Prolonged standing is associated with increased odds of preterm delivery (odds ratio, 1.11; 95 % CI = 1.02–1.22) just as the total lifted weights (*OR* = 1.31; 95 % CI = 1.11–1.56) whereas heavy physical loads are associated with having a low birthweight neonate (odds ratio, 1.79; 95 % CI = 1.11–2.87) [11, 12].

Therefore, we analyzed available materials about likely adverse health effects upon exposure to specific components of work hardness in several occupational groups. As a result, we established that work hardness components were heterogeneous for similar occupations in different industries and likely adverse effects were also variable. It should be noted that when this approach is taken, the maximum full list of adverse effects can be created allowing for influence exerted by those work hardness components, which are not conventionally considered as able to cause OD development (body bending or physical displacement).

Our analysis of research literature with data on effects produced by work hardness on workers' health allowed us to create a list of likely diseases (per specific classes of diseases in ICD-10) allowing for detailed work hardness indicators per specific components (Table 2) [2, 4–18, 22].

Completion of the *second stage* in hazard identification showed that not all likely adverse effects were confirmed considering biological pathways of their development.

Pathogenesis of back pains and associated pain syndromes (neck, chest and low back pains) caused by static and dynamic exogenous exposures (lifting and moving heavy weights, a forced working posture, and body bending) involves considering tone disorders in skeletal muscles, which, together with compression of nerve structures (trunks and roots) induce degenerative and dystrophic changes in the spine with subsequent disruption of microcirculation aggravating these initiated dystrophic changes[8] [17, 18].

Table 2

Work-related diseases caused by work hardness taking into account its detailed components [2–19]

№	Likely diseases	1. Dynamic physical load, kg·m		2. Weight of cargo lifted and moved manually, kg		3. Stereotypical working movements, absolute		4. Static load, kg·sec		5. Working posture, % of time		6. Body bends, absolute	7. Physical displacement, km
		Regional	Total	Single	Permanent	Local	Regional	Regional	Total	Forced	Standing		
	Diseases of the musculoskeletal system and connective tissue (M00–M99)												
1	Dorsopathies – M50–54 / dorsalgia – M54		■	■	■		■		■	■	■	■	■
2	dorsopathies / intervertebral disc disorders – M50–51			■	■					■			
3	Periarthritis of shoulder (shoulder lesion) – M75			■	■				■	■	■	■	
4	Arthrosis and polyarthrosis– M15–19			■	■				■	■	■	■	
5	Myositis – M60			■	■				■	■	■	■	
	Diseases of the nervous system (G00–G99)												
4	Polyneuropathy of upper extremities / other specified polyneuropathies – G62.8			■						■	■		
	Diseases of the genitourinary system (N00–N99)												
5	Chronic tubulo-interstitial nephritis – N11			■			■		■	■	■		
6	Salpingitis and oophoritis – N70			■			■		■	■	■		
7	Inflammatory disease of uterus, except cervix – N71			■			■		■	■	■		
	Diseases of the circulatory system (I00–I99)												
8	Hypertensive diseases – I10–15		■	■			■		■	■	■	■	
9	Ischaemic heart diseases – I20–25		■	■						■	■	■	
10	Varicose veins of lower extremities – I83			■			■		■	■	■		
	Pregnancy, childbirth and the puerperium (O00–O99)												
11	Spontaneous abortion (miscarriage) – O03			■								■	
12	Pre-eclampsia – O14			■								■	
13	Low birth weight – P07		■		■								
14	Preterm labour and delivery – O60				■						■		
	Diseases of the digestive system (K00–K93)												
15	Gastritis and duodenitis – K29			■			■		■	■	■		
16	Functional dyspepsia – K30			■			■		■	■	■		
17	Haemorrhoids – K64			■			■		■	■	■		
18	Disorders of gallbladder – K80–87			■			■		■	■	■		
	Endocrine, nutritional and metabolic diseases (E00–E90)												
19	Obesity – E66									■			■
20	**Diseases of the skin and subcutaneous tissue (L00–L99)**			■	■		■				■	■	
	Diseases of the eye and adnexa (H00–H59)												
21	Disorders of choroid and retina – H30-36			■			■		■	■	■		

The cardiovascular system is a leading component in regulation of the body vital activities including exposures to heavy physical loads. Disorders of the circulatory system develop due to overstrain of adaptation mechanisms and gradual depletion of functional reserves. This induces changes in parameters of nuerohumoral regulation involving destabilization of vegetative control with prevailing sympathetic activity (hyper sympathicotonia) and impaired vascular tone [16, 19–21].

Diseases of the digestive system can develop due to changes in intraperitoneal pressure when lifting and moving heavy weights (hemorrhoids) and disrupted circulation when working in a forced posture (gastritis or functional dyspepsia). Elevated intraocular pressure and disrupted circulation in the choroid and retina explains detected diseases of the eye and adnexa caused by exposure to such work hardness components as lifting heavy weights and body bending. Changes in intraperitoneal pressure and circulation in the uterine play a significant role in pathogenesis of such effects as unfavorable pregnancy outcomes (miscarriage) due to lifting heavy weights, working

standing and body bending when performing work tasks [11, 22].

At the same time, we did not find any confirmation of associations between diseases of the skin and subcutaneous tissue and endocrine disorders (obesity) and exposure to work hardness components when analyzing pathogenetic pathways of their development. Therefore, these diseases can be excluded from the list of WRD created at the first stage in hazards identification.

Completion of the *last stage* in hazard identification involved selecting likely adverse effects considering detailed analysis of work hardness components and creating a hazard identification matrix containing a list of likely health outcomes (WRD per classes of diseases) associated with work hardness components for workers from the analyzed occupational groups (Examples are provided in Tables 3.1 and 3.2).

Table 3.1

Hazard identification matrix with the list of likely health outcomes (WRD per classes of diseases) associated with components of heavy physical loads exemplified by operator at processing production

Work hardness components	Likely effects per classes of diseases
	Diseases of the musculoskeletal system and connective tissue (M00–M99)
1. Dynamic physical load, kg·m	
2. Weight of cargo lifted and moved manually, kg	*RR* > 1 (2.2)
3. Stereotypical working movements, absolute	
4. Static load, kg·sec	
5.1. Working posture (uncomfortable /forced), % time	
5.2. Standing, % time	
6. Body bends, absolute	*RR* > 1 (2.2)
7. Physical displacement, km	

Note here and after: *RR* values are given at 95 % CI > 1.

Table 3.2

Hazard identification matrix with the list of likely health outcomes (WRD per classes of diseases) associated with components of heavy physical loads exemplified by operator at bakery

Work hardness components	Likely effects per classes of diseases				
	Diseases of the musculoskeletal system and connective tissue (M00–M99)	Diseases of the circulatory system (I00–I99)	Diseases of the digestive system (K00–K93)	Diseases of the eye and adnexa (H00–H59)	Diseases of the genitourinary system (N00–N99)
1. Dynamic physical load, kg·m	*RR* > 1 (1.66)	*RR* >1 (2.29)	*RR* > 1 (1.95)	*RR* > 1 (2.2)	*RR* > 1 (1.91)
2. Weight of cargo lifted and moved manually, kg					
3. Stereotypical working movements, absolute	*RR* > 1 (1.66)	*RR* > 1 (2.29)	*RR* > 1 (1.95)	*RR* > 1 (2.2)	*RR* > 1 (1.91)
4. Static load, kg·sec					
5.1. Working posture (uncomfortable /forced), % time					
5.2. Standing, % time					
6. Body bends, absolute					
7. Physical displacement, km					

Work activities tend to have a complex structure and work hardness is usually described with indicators that vary for different occupational groups. Bearing this in mind, we should remember that this hazard identification matrix is a dynamic instrument, which can be adjusted and supplemented as new epidemiological and clinical data become available.

Conclusion. We suggest considering not only OD but also WRD as likely health effects upon exposure to work hardness, its specific components taken into account, at the hazard identification stage. More precisely defined approaches (an algorithm) to hazard identification upon long-term exposure to heavy physical loads involve analyzing a relationship established for specific occupational groups typically exposed to certain work hardness components with subsequent health effects; confirming WRD biological plausibility allowing for pathogenetic pathways of their development; creating a hazard identification matrix containing a list of likely diseases. We visualized the OD list and created a list of WRD, which were likely to develop upon exposure to specific components of work hardness. Use of such adjustments makes it possible to consider components not established as regards OD development (body bending and physical displacement).

The suggested approaches were tested in hazard identification accomplished for such occupations as operators, loaders, and mechanics at various productions. As a result, it was established that diseases of the musculoskeletal system and connective tissue (M00–M99), nervous system (G00–G99), circulatory system (I00–I99), digestive system (K00–K93), genitourinary system (N00–N99), as well as diseases of the eye and adnexa (H00–H59) should be considered work-related diseases (WRD) whereas diseases of the skin and subcutaneous tissue (L00–L99) as well as endocrine diseases (E00–E90) did not belong to WRD. A hazard identification matrix was created by detailed analysis of the relationship between components of work hardness and likely health outcomes (per classes of diseases).

Use of the developed approaches ensures creating a proper theoretical base for hazard identification within occupational health risk assessment; allows minimizing uncertainties and unifying the assessment process due to detailed consideration of specific components. It can be recommended as a supplement to the Guide R 2.2.3969-23. Assessment of Occupational Health Risk for Workers. Organization and Methodical Essentials, Principles and Assessment Criteria.

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References

1. Abdelsalam A., Wassif G.O., Eldin W.S., Abdel-Hamid M.A., Damaty S.I. Frequency and risk factors of musculoskeletal disorders among kitchen workers. *J. Egypt. Public Health Assoc.*, 2023, vol. 98, no. 1, pp. 3. DOI: 10.1186/s42506-023-00128-6

2. Zaitseva N.V., Shur P.Z., Lir D.N., Alekseev V.B., Fokin V.A., Barg A.O., Novikova T.A., Khrushcheva E.V. Posterior assessment of occupational risks associated with work hardness based on workers' subjective perception of their health. *Health Risk Analysis*, 2024, no. 3, pp. 55–66. DOI: 10.21668/health.risk/2024.3.07.eng

3. Lir D.N., Shur P.Z., Zaitseva N.V., Alekseev V.B., Novikova T.A., Barg A.O., Khrushcheva E.V. Prior assessment of the occupational health risk according to workers' subjective perception of work hardness. *Gigiena i sanitariya*, 2024, vol. 103, no. 5, pp. 440–448. DOI: 10.47470/0016-9900-2024-103-5-440-448 (in Russian).

4. Valeeva E.T., Karimova L.K., Galimova R.R., Muldasheva N.A., Distanova A.A. Assessment of occupational health risk for workers employed at contemporary rubber production. *Health Risk Analysis*, 2020, no. 1, pp. 59–67. DOI: 10.21668/health.risk/2020.1.06.eng

5. Novikova T.A., Aleshina Yu.A., Lucevich I.N., Musaev Sh.Zh. Working conditions and occupational health risks for workers employed at bakeries. *Gigiena i sanitariya*, 2020, vol. 99, no. 8, pp. 809–815. DOI: 10.47470/0016-9900-2020-99-8-809-815 (in Russian).

6. Karimova L.K., Galimova R.R., Shaikhlislamova E.R., Muldasheva N.A., Mavrina L.N., Gabdulvaleeva E.F. The effect of harmful industrial factors on the space-space of chronic noninfectious life in employees rubber. *Meditsina truda i ekologiya cheloveka*, 2019, no. 3 (19), pp. 15–22. DOI: 10.24411/2411-3794-2019-10031 (in Russian).

7. Novikova T.A., Bezrukova G.A., Kochetova N.A., Makarevskaya D.M. Risk of Occupational Diseases in Workers of Contemporary Petroleum Refining. *ZNiSO*, 2024, vol. 32, no. 10, pp. 26–35. DOI: 10.35627/2219-5238/2024-32-10-26-35 (in Russian).

8. Novikova T.A., Spirin V.F., Aleshina Yu.A. Occupational risk to the health of dairy products manufacturing workers. *Gigiena i sanitariya*, 2020, vol. 99, no. 11, pp. 1230–1235. DOI: 10.47470/0016-9900-2020-99-11-1230-1235 (in Russian).

9. Iwakiri K., Sasaki T., Sotoyama M., Du T., Miki K., Oyama F. Effect of relative weight limit set as a body weight percentage on work-related low back pain among workers. *PLoS One*, 2023, vol. 18, no. 4, pp. e0284465. DOI: 10.1371/journal.pone.0284465

10. Iwakiri K., Sasaki T., Du T., Miki K., Oyama F. Manual rolling load and low back pain among workers in Japan: a cross-sectional study. *J. Occup. Health*, 2024, vol. 66, no. 1, pp. uiae015. DOI: 10.1093/joccuh/uiae015

11. Cai C., Vandermeer B., Khurana R., Nerenberg K., Featherstone R., Sebastianski M., Davenport M.H. The impact of occupational activities during pregnancy on pregnancy outcomes: a systematic review and metaanalysis. *Am. J. Obstet. Gynecol.*, 2020, vol. 222, no. 3, pp. 224–238. DOI: 10.1016/j.ajog.2019.08.059

12. Iwakiri K., Miki K., Sasaki T. Effect of manual handling weight for lifting and carrying on the severity of acute occupational low back pain. *Int. Arch. Occup. Environ. Health*, 2025, vol. 98, pp. 507–513. DOI: 10.1007/s00420-025-02148-5

13. Bazarova E.L., Varaksin A.N., Maslakova T.A., Konstantinova E.D., Fedoruk A.A., Osherov I.S. Leading Risk Factors for Diseases of the Circulatory and Musculoskeletal Systems in Metallurgical Workers. *ZNiSO*, 2023, vol. 31, no. 11, pp. 50–57. DOI: 10.35627/2219-5238/2023-31-11-50-57 (in Russian).

14. Shaikhlislamova E.R., Valeyeva E.T., Karimova L.K. Working conditions and specific features of development of the nervous and musculoskeletal systems diseases in workers of chemical industry. *ZNiSO*, 2018, vol. 300, no. 3, pp. 11–14 (in Russian).

15. Novikova T.A., Migacheva A.G., Bezrukova G.A., Aleshina Yu.A., Kochetova N.A. Working conditions and the prevalence of chronic non-communicable diseases among workers in the production of polyacrylonitrile fibers. *Gigiena i sanitariya*, 2023, vol. 102, no. 5, pp. 445–451. DOI: 10.47470/0016-9900-2023-102-5-445-451 (in Russian).

16. Migacheva A.G., Novikova T.A., Spirin V.F. The impact of the labor process severity on the formation of health disorders of protected ground grower. *Gigiena i sanitariya*, 2021, vol. 100, no. 6, pp. 598–604. DOI: 10.47470/0016-9900-2021-100-6-598-604 (in Russian).

17. Rukavishnikov V.S., Kolesov V.G., Shayakhmetov S.F., Pankov V.A. Locomotory disorders in workers engaged into mining industry of north regions. *Meditsina truda i promyshlennaya ekologiya*, 2004, no. 7, pp. 9–14 (in Russian).

18. Konstantinov R.V., Loginova N.N. Occupational dorsopathy: topics of occupational examination and rehabilitation. *Meditsina truda i promyshlennaya ekologiya*, 2004, no. 12, pp. 16–20 (in Russian).

19. Shlyakhto E.V., Konradi A.O., Zvartau N.E., Nedogoda S.V., Lopatin Yu.M., Sitnikova M.Yu., Mikhailov E.N., Baranova E.I., Galyavich A.S., Duplyakov D.V., Salasyuk A.S., Galagudza M.M. Influence on the autonomic cardiovascular system regulation in the treatment of hypertension, arrhythmias and heart failure. *Rossiiskii kardiologicheskii zhurnal*, 2022, vol. 27, no. 9, pp. 5195. DOI: 10.15829/1560-4071-2022-5195 (in Russian).

20. Vorob'eva A.A., Vlasova E.M., Ustinova O.Yu., Fokin V.A. Vegetativnaya disfunktsiya kak prediktor arterial'noi gipertenzii u rabotayushchikh vo vrednykh usloviyakh truda [Vegetative dysfunction as a predictor of arterial hypertension in workers in harmful working conditions]. *Analiz riska zdorov'yu – 2022: Fundamental'nye i prikladnye aspekty obespecheniya sanitarno-epidemiologiches-*

kogo blagopoluchiya naseleniya sovmestno s mezhdunarodnoi vstrechei po okruzhayushchei srede i zdorov'yu RISE-2022: materialy XII Vserossiiskoi nauchno-prakticheskoi konferentsii FBUN «FNTs mediko-profilakticheskikh tekhnologii upravleniya riskami zdorov'yu naseleniya» s mezhdunarodnym uchastiem: in 2 volumes, Perm, May 18–20, 2022, vol. 2, pp. 17–27 (in Russian).

21. Safaryan A.S., Sargsyan V.D. Sympathetic hyperactivity in patients with hypertension: pathogenesis and treatment. Part I. *Kardiovaskulyarnaya terapiya i profilaktika*, 2020, vol. 19, no. 6, pp. 2693. DOI: 10.15829/1728-8800-2020-2693 (in Russian).

22. Mozurkewich E. Working conditions and pregnancy outcomes: an updated appraisal of the evidence. *Am. J. Obstet. Gynecol*., 2020, vol. 222, no. 3, pp. 201–203. DOI: 10.1016/j.ajog.2019.11.1263

Shur P.Z., Lir D.N., Alekseev V.B., Ustinova O.Yu., Fokin V.A., Khrushcheva E.V., Zaitseva N.V. Identifying health threats in occupational health risk assessment upon exposure to work hardness considering detailed analysis of its separate components. Health Risk Analysis, 2025, no. 3, pp. 61–71. DOI: 10.21668/health.risk/2025.3.07.eng

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