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Physical Agents and Occupational Disease Compensation: Noise, Vibration, Radiation, and Other Physical Agents

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The context of specific criteria for the recognition of occupational diseases (ODs) due to physical agents in the Enforcement Decree of the Industrial Accident Compensation Insurance Act (ED-IACIA) and the Labor Standard Act (LSA) does not describe definite disease along with the agents but listed symptoms or obscure clinical conditions. Moreover, the needs for an amendment of these Acts have recently attracted renewed interest. To establish agreed criteria for compensable ODs due to physical agents, we reviewed the criteria for recognizing ODs on the basis of International Labor Organization (ILO) documents and European Union (EU) guideline. After providing a brief review of the history of OD outbreaks due to physical exposure in South Korea and the responses to them, we describe the basis for the recent amendments to the IACI Act and LSA and assess their appropriateness. On the basis of these findings, this study could be helpful for determining and compensating process of ODs. However, further work is required to ascertain the scientific relationship between diseases caused by physical agents and the exposure criteria.

Keywords: Physical Agents; Occupational Disease; Workers' Compensation; Legislation; Recognition Criteria

INTRODUCTION

In general, physical agents workers are exposed to include noise, vibration, radiation (ionizing and non-ionizing), pressure (compressed or decompressed), and extreme temperature. The health effects and target organs of these agents vary greatly with their nature. In contrast to other factors, we cannot detect these agents by sensory organs such as the eyes, nose, and taste buds. Therefore, a variety of scientific disciplines, detection techniques, and instruments as well as adequately trained and experienced persons are needed for measurement (1). Moreover, because of wide variations in individual susceptibility, exposure to an individual may result in annoyance, aggravation of a pre-existing condition, or physiological damage. In Korea, the legal system for workers' compensation is a top priority in the social security system. Occupational diseases (ODs) are covered by the workers' compensation system; however, the system still can miss many unclaimed or unrecognized cases (2). In addition, there exists some controversy on the approval of ODs caused by physical agents.

At this point, the agreed criteria for compensating for ODs will help in ensuring consistency in clinical decisions, and contribute to the management of individual cases and the prevention of disease in occupationally-exposed groups.

MATERIALS AND METHODS

The authors reviewed the scope of compensable ODs in the Enforcement Decree of the LSA (ED-LSA) and the specific recognition criteria for ODs in the Enforcement Decree of the IACI Act (ED-IACIA), since the two acts are closely related. They excluded diseases due to accidents, and pneumoconiosis, to which special regulations apply. The International Labor Organization (ILO) list of ODs was reviewed in detail, cases in some other countries and their lists of ODs were referred to. To identify the newly identified risk factors and ODs, cases investigated by the Korea Occupational Safety and Health Agency (KOSHA) and Occupational Lung Diseases Institute of the Korea Workers' Compensation and Welfare Service (OLDS of KCOMWEL), those recognized as work-related, official domestic exposure status, and the recent scientific literature were reviewed, and opinion was invited from the occupational medicine professions. Based on these data, the risk factors and established causal relationships of ODs were listed; however, this required revision of the scope and the recognition criteria in light of the domestic exposure conditions. In addition the directions for the revision of the scope, criteria, and systematization of ODs in Korea were specified. All the above mentioned procedures for amending the specific recognition criteria for ODs in ED-IACIA and ED-LSA are described in Song et al. (3).

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RESULTS

History and present condition of occupational diseases caused by physical agents

Noise-induced hearing loss (NIHL) is the second common OD. Since 1991, annually 200-300 cases of NIHL are compensated, including sudden hearing loss. Hand-arm vibration syndromes (HAVS) have been reported in workers using grinders that produced hand-transmitted vibrations. Approximately, 15 cases of HAVS are compensated in a year. Heat related diseases such as heat stroke were also reported. Diseases caused by compressed and decompressed air have been continuously reported (4, 5). Radiation-related diseases such as leukemia were reported recently; these cases of radiation exposures were attributed to the use of non-destructive examinations (6) (Table 1).

Present criteria of work-related diseases caused by physical agents

Noise-induced hearing loss (NIHL)

NIHL is compensated as a work-related disease by the Industrial Accident Compensation Insurance (IACI) Act. The compensation criteria are as follows: 1) workers should have been working or have a history of working in workplaces with continuous noise of more than 85 dB for more than 3 yr, 2) the hearing loss should be of the sensorineural type and the average of the threshold calculation formula (hearing threshold of 500 Hz+ 2*1,000 Hz+ 2*2,000 Hz+ 4,000 Hz)/6 should be more than 40 dB for at least one ear, 3) Workers' symptoms should meet the following requirements: a) no obvious lesions in the eardrum or middle ear; b) no obvious difference between air and bone conduction hearing threshold on pure tone audiometry, and a high-frequency hearing loss higher than the low-frequency; 3) hearing loss that is not caused by labyrinthitis, drug addiction, febrile diseases, Meniere's syndrome, syphilis, head trauma, sudden hearing loss, genetic hearing loss, familial hearing loss, senile deafness, or accidental blasts.

Hand-arm vibration syndrome (HAVS)

The compensation criteria for HAVS are as follows: 1) workers who have been working or have a history of working in workplaces with vibration-transmitting tools such as air rock drills and chain saws; and 2) workers who have the necessary conditions (symptoms or signs) from the followings: a) temporary or continuous subjective symptoms such as numbness, pain, cold sensation, and stiffness in the finger or the wrist; and at least one of the following disorders that manifest in the finger or the wrist: i) vascular symptoms, ii) sensorineural symptoms, iii) musculoskeletal symptoms; and b) Raynaud's phenomenon.

Diseases caused by atmospheric compression or decompression

In workers who were exposed to compressed atmosphere such as underwater work environment and caissons, or exposed to a pressure below that of the ground level, if there are any of following disorders (symptoms or signs) they could be considered to have work-related disease; 1) disorders that appear from 6 to 12 hr after exposure to compressed or decompressed conditions: barotraumas of the lungs, middle ear, sinuses, and teeth; barotraumas due to SCUBA; nitrogen narcosis or oxygen toxicity of the central nerve system (CNS); dysbaric disorders of the skin, musculoskeletal system, respiratory system, CNS, or inner ear; air embolism in the cerebral or coronary artery; pneumothorax, hemothorax, or formication in the pericardium or subcutaneous area; pain on the back or abdomen, severe fatigue. 2) dysbaric osteonecrosis that appears in workers have been working for more than 2 months or have a history of working in workplaces with dysbaric conditions. Further, the osteonecrosis should not have been caused by chronic alcoholism, syphilis, diabetes, liver cirrhosis, hepatitis, rheumatic arthritis, dyslipidemia, thrombocytopenia, gout, Raynaud's syndrome, polyarteritis nodosa, alkaptonurea, and medicine.

Other diseases caused by physical agents

If workers who were exposed to the following physical agents in

Table 1. Compensated occupational diseases of the recent 11 yr (source: Annual Statistics of Ministry of Employment and Labor)

Year	Total	NIHL	CDP	HAVS	PA	PNEU	CS2	TCE	OS	BEN	DI	ARD	SOC	HM	INF	DER	Others
2001	1,116	287	2		12	567	27		11	1	4		22	23	102		58
2003	1,423	314	4	22	2	867	9	2	10	6	6	3	33	17	127		
2004	2,046	266	4	2	5	1,522	6		11	5	6	5	14	18	165		17
2005	2,069	302	2	16	9	1,564	1	2	9	1	4	4	20	10	99		26
2006	1,650	272	4	9	9	1,132	2	2	5	3	8	3	34	7	125	29	6
2007	1,618	237	4	16	26	980		2	17	3	10	10	108	5	181	19	
2008	1,190	220	6	7	6	719		3	3	1	3	11	37	8	129	37	
2009	1,315	205	3	9	4	606		1	2	2	1	19	21	2	419	20	1
2010	1,129	266	2	15	13	530	15		9	1	6	7	8	2	211	35	9
2011	1,162	268	2	23	5	639	1		3	2	5	10	11	1	157	19	16

NIHL, noise induced hearing loss; CDP, compressed or decompressed pressure; HAVS, hand-arm vibration syndrome; PA, other physical agents; PNEU, pneumoconiosis; CS2, carbon disulfide; TCE, trichloroethylene; OS, other organic solvent; BEN, benzene; DI, di-isocyanate; ARD, asbestos related disease; SOC, specific organic chemicals; HM, heavy metal; INF, infection; DER, skin disease.

the workplace have any of the following disorders (symptoms or signs), they could be considered to have work-related disease: 1) facial disorders or skin diseases due to work-related exposure to ultraviolet radiation; 2) ocular disorders such as retinal burn and cataract due to work-related exposure to infrared radiation; 3) ocular disorders such as retinal burn or skin disorders due to work-related exposure to a LASER; 4) ocular disorders such as cataract due to work-related exposure to microwave; 5) diseases caused by work-related exposure to ionizing radiation, such as: radiation skin disorders (acute radio-epidermatitis and skin ulcers), radiation ocular disease (cataract), radiation pneumonitis, hematopoietic disorder (aplastic anemia), and bone necrosis; 6) heat stroke due to work in a warm or hot workplace; 7) skin burn (above 2nd degree) caused by dealing with hot materials; and 8) frostbite (above 2nd degree) caused by dealing with cold materials or work in the cold workplace.

Problems with the present criteria and suggested revisions

The present criteria for diseases relevant to physical agents are classified by working fields or conditions exposing the worker to each agent. Moreover, the context does not describe definite diseases along with these agents but lists symptoms or obscure clinical conditions. Annexure 3 describes only seven kinds of hazard factors (ultraviolet, infrared, LASER, microwave, hazardous radiation, hot or cold workplace, and tasks dealing with hot or cold objects). Meanwhile, other diseases caused by physical agents such as compressed or decompressed air, noise, and vibration are listed separately in another annexure. However, the listed diseases or symptoms relevant to physical agents are obscure or unclear.

The objectives of this review are to update the existing physical agents and to clarify the diseases relevant to these agents. For this purpose, we adapt the definition of OD and two main elements from ILO: the term "occupational disease" covers any disease contracted as a result of an exposure to risk factors arising from work activity; the "main elements" are 1) the causal relationship between exposure in a specific working environment or work activity and a specific disease; and 2) the fact that the disease occurs among a group of exposed persons with a frequency above the average morbidity of the rest of the population.

Revision process and outcomes

The practical updating process of these criteria are as followings: 1) most cases of compressed or decompressed air, noise, and vibration to be kept on the existed classification and diagnostic criteria; 2) ultraviolet, infrared, LASER, and microwave rays are reclassified as non-ionizing radiation; 3) hazardous radiation is changed into ionizing radiation; and 4) a hot or cold workplace, and tasks dealing with hot or cold objects changed into exposure to extreme temperature. Moreover, we reconstruct the diagnostic criteria of ODs on the basis of the EU guideline (Table 2).

Further, we aim to consider the exposure context as follows: 1) the minimum level of exposure that is required to cause a disease; 2) the shortest exposure period for which a disease can occur; 3) the length of time from the cessation of exposure; and 4) the shortest period from the beginning of exposure to the beginning of disease. Exposure to physical agents is repeated and continued in the workplace, and the latent period (number 3) may not include the period of exposure to some of these agents.

All the diseases listed below and believed to be of an occupational origin are described on the basis of a causal relationship, connection with a specific work environment, and scientific evidence. The list consists of the revised physical agents, exposure sources, and the related diseases to meet the general criteria for identification as an OD (Table 3).

DISCUSSION

The objective of this study was to review the present compensation criteria and to update them. Most of the diseases caused by physical agents mentioned in the IACI Act lacked evidence for the approval of diagnosis and the exposure criteria. Therefore, we suggest clarifying the diseases and the revising exposure criteria. During the revision, we mainly referred to the "List of occupational diseases" of the ILO and "Information notices on occupational diseases: A guide to diagnosis" of the European Commission (7, 8).

Table 2. Key criteria for diagnosing an occupational disease (summary of EU guideline*)

No	Key criteria	Explanation
1	The clinical features must fit in with what is known about the health effects following exposure to the specified agent.	The symptoms and signs should fit, and this may be supported in some cases by suitable diagnostic tests.
2	There must be indication of sufficient occupational exposure.	Evidence on exposure may be obtained through taking the occupational history, results of occupational hygiene measurements taken at the workplace, biological monitoring results, and/or records of incidents of over-exposure.
3	The time interval between exposure and effect must be consistent with what is known about the natural history and progress of the disease.	Exposure must precede health effects. However, in some conditions such as occupational asthma, a past history of childhood asthma and/or asthmatic attacks occurring before occupational exposure, does not automatically rule out the possibility of a workplace agent causing subsequent asthmatic attacks.
4	The differential diagnosis must be considered.	There are non-occupational conditions that have similar clinical features as occupational diseases, and a physician will have to take this into account before diagnosing or excluding an occupational disease.

*Information notices on occupational diseases: a guide to diagnosis. Luxembourg: Office for Official Publications of the European Communities, 2009: 227-261.

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Table 3. Suggested revision criteria of occupational diseases caused by physical agents

Agents	Exposure sources or conditions	Diseases	ICD-10*
Non-ionizing radiation	Infrared, Ultraviolet, Microwaves	Skin: Erythema, skin burns, Skin cancers: basal cells and spinocellular epitheliomas and malignant melanomas	L53.9 (Erythema), T20.0 (Skin burns), C43-C44 (Melanoma and other malignant neoplasms of skin)
Infrared	Solar radiation, sources of radiant heat, industrial lasers	Blepharitis, keratitis, retinal disorders, Glass workers' cataract (Heat-induced cataract)	H01.0 (Blepharitis), H16.8 (Other keratitis), H35.8 (Other specified retinal disorders), H26.8 (Other specified cataract)
Ultraviolet (UV)	Bactericidal lamps, plasma arc and xenon welding, solar radiation especially at high altitudes, industrial lasers	Keratoconjunctivitis, Photoretinitis, Actinic cataract	H16.2 (Keratoconjunctivitis), H31.0 (Solar retinopathy), H26.8 (Cataract)
Visible light	Blue light emitted ad 400 to 550 nm or broad spectrum light emitted at high power (xenon projectors, arc lamps, flashguns)	Photoretinitis	H31.0 (Solar retinopathy)
	Underground work	Miners' nystagmus	H55 (Nystagmus)
Microwaves	Microwave oven, diode, radio telescope	Heat cataract	H26.8 (Cataract)
Ionizing radiation	X-ray machines, particle accelerators, gamma radiography sources, cobalt bombs, nuclear reactors, laboratory equipment, work involving isotopes, uranium mines	Non-random (non-stochastic) effects: Acute effects	
		Whole body irradiation: Medullar aplasia	D61.9 (Medullary hypoplasia)
		Partial-body irradiation: Acute radio-epidermatitis, Alopecia	L63.1 (Alopecia universalis)
		Oligospermia and azoospermia	N46 (Azoospermia, Oligospermia)
		Delayed effects: Cataract	H26.8 (Cataract)
		Chronic radiodermatitis: Atrophy, hyperkeratosis or telangiectasia, possibly complicated by radionecrosis	L58.1 (Radiodermatitis)
		Effects on reproduction and teratogenesis	
		Cerebral deformities (e.g. microcephalus) and skeletal deformities	Q02 (Microcephaly), M21 (Other acquired deformities of limbs)
		Mental retardation	F70-F79 (Mental retardation)
		Random (stochastic) effects:	
		Cutaneous, leukemia, primary cancer of the lung, osteosarcoma	C91-C95 (Leukemia) C34 (Malignant neoplasm of bronchus and lung) C40-C41 (Malignant neoplasm of bone and articular cartilage of limbs, Malignant neoplasm of bone and articular cartilage of other and unspecified sites)
Noise	This document covers only the effects of noise to the auditory system	Acute effects	
		Neurosensory effects: Dizziness, tinnitus, hypoacousis which can lead to total deafness	R42 (Dizziness), H93.1 (Tinnitus) H91.9 (Hearing loss, unspecified)
		Physical damage: Laceration of the tympanic membrane	H72.8 (Other perforations of tympanic membrane)
		Chronic effects	H91.9 (Hearing loss, unspecified)
		Occupational hearing loss	
Atmospheric compression or decompression	Professional divers and those working in compressed air	Acute effects	
		Barotrauma of the middle ear, inner ear, sinuses, lungs	T70.0 (Otitic barotrauma), T70.1 (Sinus barotrauma), T70.2 (Other and unspecified effects of high altitude)
		Toxic effects of inhaled gases: Nitrogen narcosis	
		Hypo-oxemic attack: Convulsions preceded by cramp, dizziness and nausea	T59 (Toxic effect of other gases, fumes and vapours)
		High pressure neurological syndrome: Tremors, muscle contractions, dizziness and nausea	
		Decompression diseases: Bends, Osteoarticular pain, Subcutaneous formication	T70.3 (Caisson disease , decompression sickness)
		Neurological disturbances: Paraplegia, etc.	
		Chronic effects	
		Hypoacusis: Caused by irreversible cochlear damage with or without labyrinthic syndrome	
		Dysbaric osteonecrosis: Affecting the shoulder, hip, or knee with characteristic skeletal X-ray picture	M87.8 (Other osteonecrosis)
Pressure below that of ground level atmospheric pressure	Passengers of modern aircraft to breathe without using masks the cabins of both pilot and passenger	Acute effects: Barotrauma of the middle ear	T70.0 (Otitic barotrauma)
	Modern fire protection systems in storerooms working by reduction of the oxygen content of the air down to 13% of oxygen	Cognitive impairments, Headache, Dizziness, Tiredness, Tachycardia, Lowering of the blood pressure	

(Continued to the next page)

Table 3. Continued

Agents	Exposure sources or conditions	Diseases	ICD-10*
Vibration: hand-arm vibration (HAV)	Vibration transmitted tools such as grinding, spinning, fettling, using a grinding wheel, chainsaw, high pressure water hose, hammer drill, rammer, chisel, chipping hammer or other pneumatic tools frequency range 5-1,500 Hz, but usually 125-300 Hz	Vibration-induced white fingers (Raynaud's phenomenon of occupational origin) Peripheral sensorineural polyneuropathy Osteoarthrosis of the elbow and wrist Osteonecrosis of the semilunate bone (Kienböck's disease) Pseudoartrosis of the scaphoid bone contracture of the palmar aponeurosis (Dupuytren's disease)	T75.2 (Effects of vibration, Pneumatic hammer syndrome, Traumatic vasospastic syndrome, Vertigo from infrasound) M93.1 (Kienböck's disease) M72.0 (Dupuytren's disease)
Extreme temperature (high temperature)	Workers at risk are steel workers, oven and furnace operators, glassblowers, farmers, ranchers, fishermen, and construction workers	Heat stroke, heat exhaustion, heat clamps, heat syncope, and skin disorders	T67 (T67.0-T67.9) T67.0 (Heatstroke), T67.3 (Heat exhaustion, anhydrotic), T67.4 (Heat exhaustion due to salt depletion), T67.5 (Heat exhaustion, unspecified) T67.2 (Heat cramp), T67.1 (Heat syncope)
Extreme temperature (low temperature)	Workers exposed to cold such as meat packers, work with freezers, construction workers, cold room personnel, fishermen, woodmen, drivers, mail carriers, fire-fighters, and road maintains workers	Hypothermia, frostbite, immersion foot	T68 (Hypothermia), T33-35 (Frostbite), T69.0 (Immersion hand and foot)

*International Classification of Diseases-Version 10.

Diseases such as hearing impairment caused by noise, vibration (disorders of muscles, tendons, bones, joints, peripheral blood vessels or peripheral nerves), and compressed or decompressed air mentioned in the present IACI Act were relatively well described. Therefore, we added the exposure criteria and several diseases relevant to physical agents.

According to the ILO document, "Diseases caused by physical agents" are as follows: 1) hearing impairment caused by noise, 2) diseases caused by vibration (disorders of muscles, tendons, bones, joints, peripheral blood vessels or peripheral nerves), 3) diseases caused by compressed or decompressed air, 4) diseases caused by ionizing radiations, 5) diseases caused by optical (ultraviolet, visible light, infrared) radiations including laser, and 6) diseases caused by exposure to extreme temperatures. Further, if the exact relationship of the diseases with physical agents could not be define, the principle of all-inclusiveness on the basis of scientific evidence was adapted. Hence, the document included an additional item, 7) diseases caused by other physical agents at work, not mentioned in the preceding items where a direct link was established scientifically, or determined by methods appropriate to national conditions and practice, between the exposure to these physical agents arising from work-related activities and the disease(s) contracted by the worker.

This study described the detailed exposure criteria as well as specific physical agents and the relevant diseases. However, an issue that was raised but remained unsolved was whether new diseases caused by physical agents could be included or not. In the case of "diseases due to radiofrequency radiations", there was a lack of medical knowledge about the effects of such exposures and difficulties in diagnosis although the discussion focused on the scientific basis. With the current controversy over risks from electromagnetic fields (EMF), several experts mentioned the proven thermal effects of such radiation, which resulted in tissue damage in humans such as cataracts and other diseases such as male infertility. However, it was pointed out that this would exclude diseases that may be caused by non-thermal effects of radiofrequency radiations. For the diseases caused by non-ionizing radiation (ultraviolet, visible light, or infrared), there were concerns about the practical difficulties of distinguishing between occupational and non-occupational exposure. If a worker developed malignant melanoma, for example, it would be impossible to rule out the harm from natural radiation while on vacation in assessing the risk of occupational exposure. In the cases of diseases caused by extreme temperature (hot and cold conditions), further clarification of the term "extreme temperature" that take into account dryness, humidity, radiation, airflow and duration of exposure was required.

We believe that this revision will be helpful in determining the compensation process for ODs. However, further work is required to ascertain the scientific relationship between diseases caused by physical agents and the exposure criteria.

DISCLOSURE

The authors have no conflicts of interest to disclose.

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