- the ability to identify and analyze potential threats of emergencies, accidents, incidents, assess their possible consequences and risks, etc.

Thus, it can be argued that some competencies in "risk-oriented thinking", acquired by students, will enable them to address basic occupational safety issues (issues of providing proper, safe, and healthy working conditions for employees) and civil security, as envisaged by current education standards. Moreover, the state, represented by the Ministry of Education and Science of Ukraine, has provided domestic universities with the opportunity to create and implement educational disciplines with a risk-oriented focus in the field of knowledge 26 "Civil Security".

However, during the study of open sources such as educational programs, work programs of educational disciplines in universities in the field of knowledge 26 "Civil Security", publicly available elements of educational-methodical complexes of disciplines of the specialty 263 "Civil Security", scientific articles, monographs, dissertations, etc., we have found that there is no discipline that comprehensively and in-depth explores the concepts and aspects of phenomena such as risk in the field of technospheric, production, civil security, and life safety. Such a discipline would teach the laws (regularities) of risk, examine the theoretical (methodological, practical) principles of risk management, present to students the modern state position on the concept of "acceptable risk", explain the relationship between riskology and other academic disciplines, and define the required level of formation of certain sets of skills and abilities in students, which is not taught in domestic universities.

Therefore, we propose the introduction of a new educational discipline called "Safety Riskology", and in the future, the establishment of a separate scientific research direction "Safety Riskology".

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ERGONOMIC STUDIES OF THE WORKPLACE USING MOTION CAPTURE

Musculoskeletal disorders (MSDs) continue to be the main cause for occupational sick leave in countries with no foreseeable improvement. On the contrary, producing companies find themselves confronted with demographic changes leading to increasing average working age and a rise in the share of the population aged 65 and over. At the same time companies have the ethical obligation to protect the health of their workers, and the economic challenge to secure competitiveness. Therefore, companies need to adapt to the changing age structure because physical intensive tasks lead to work-induced impairments which increase with age and result in more employee absences. In order to prevent MSDs, workplaces need to be ergonomically designed and workload needs to be managed (e.g., task distribution) so that individual workers are not overloaded.

Common methods for ergonomic risk assessment usually analyze body posture and physical stress to identify critical work steps and critical workplaces. They compare measured values with fixed threshold values and compute a risk ratio for MSD occurrence for existing processes or for processes being planned. The practical application of these methods comprises several problems. Firstly, the individual physical capacity is not taken into account and physical limitations, such as age-related loss of range of motion (ROM) or decline in muscle strength, are therefore not considered. Moreover, in the ergonomic assessment of existing workplaces, it is too time consuming and cost intensive to assess every worker at every workstation. As a consequence, the results of one or a few workers are used for ergonomic improvements without taking the individual anthropometry and capacities into account. Additionally, the methods provide only an injury risk score due to bad ergonomic design.

However, the analysis does not show which type of physical workload leads to the overload of which body part, let alone suggest specific counter measures. At the same time most engineers and designers have limited expertise with human factors and ergonomics, which is why recommends that in the future, digital solutions to improve ergonomics need to help the user take decisions to design safe workplaces.

The most prominent methods for the assessment use standardized tests to determine whether a worker can return to work after an illness or injury, or to quantify the course of rehabilitation. Since each assessment takes about 5 h plus follow-up work, the application of these methods is too time-consuming and thus expensive for an entire workforce. There have been several solutions that use motion capture (mocap) systems to digitize existing functional capacity evaluations with the aim of objectifying the assessment. However, they do not substantially reduce the duration of the assessment nor do they provide a comprehensive solution to assess the worker capability and the workplace requirements. Most functional capacity evaluations include a measurement of handgrip strength. Grip strength is important for the execution of assembly and logistics tasks but also because studies have shown that it has a significant positive correlation with muscle strength of various muscle groups.

The goal of the research project was to develop an individual ergonomic analysis to assess and improve workplaces according to the worker capabilities. To achieve this goal, we used a systems engineering approach and divided the project into subsystems that were continuously evaluated and refined during the course of development (Fig. 1). It comprises a capability analysis and a requirements analysis that are performed independently from one another.

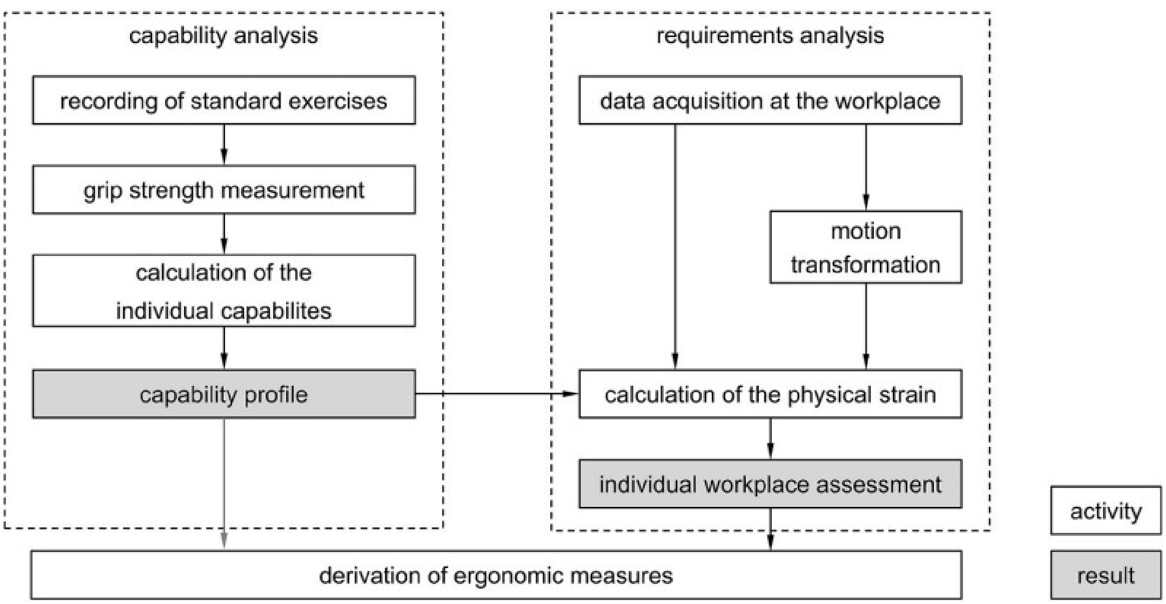

Fig. 1. Structure of the analysis.

The capability analysis assesses the individual joint mobility of a worker with a mocap system and estimates the body strength using a hand grip strength measurement. The requirements analysis assesses the physical strain during a specific working task. In order to do so, a worker wears the mocap system while executing the work task and the assessor records all weights handled by the worker, such as work pieces or tools. After processing the data, the individual physical strain is calculated with the previously created capability profile. The user can use the original kinematic data to obtain a workplace assessment for the recorded worker or can apply an automated motion transformation to obtain a workplace assessment for all workers whose capability profiles have been recorded.

The application in practice has shown that the capability analysis is easy to apply and is able to detect restrictions in joint mobility and handgrip strength. Furthermore, the requirements analysis provides valid results for assembly and logistics processes which allow the derivation of general and individual ergonomic measures. The assessed workers gave positive feedback, especially about the method addressing their individual capabilities and body size. The mocap system did not interfere with their work, however, it acted as an obstacle to some workers who did not like to wear as many sensors, and because it attracts a lot of attention from coworkers. Since only the motion sequence and the handheld loads are recorded, the analysis hardly requires any preparation time, the time effort can be considered as low and the field of application is only limited by the load types. Especially in comparison to conventional ergonomic analyses, the advantage is obvious. With an additional effort of about 30 min per employee for the capability analysis, the motion transformation enables a worker-individual workplace assessment. Furthermore, the joint-specific risk assessment and catalogs of measure help the user find effective measures to prevent physical overload.

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PROTECTIVE EARPHONES AND HUMAN HEARING SYSTEM RESPONSE TO THE RECEIVED SOUND FREQUENCY SIGNALS

Human hearing system, including outer ear, middle ear, inner ear, and related nerves depends on sound. Outer ear has the duty to collect the sounds and transfer them to the middle ear via the ear canal and to the tympanic membrane (eardrum). Sound waves pass through malleus, incus, and stapes, reaching to the inner ear. Inner ear includes cochlea and semi-circular canals. Cochlea includes thousands of very thin hair cells in the spiral organ (organ of Corti). When the sound waves enter the inner ear, the hair cell helps in stimulating the sound waves. Hair cells transform the vibrations into electric signals, and waves are transferred to the brain via hearing nerves. Brain transforms the signals into understandable sounds. Confronting with sound damages spiral organ cells. The sensing hair cells are vibrated by acoustic input signals, and then the mechanical vibrations are transformed to an electric form to reach to the eighth brain nerve. Confronting with intense sounds (over 85 dBA) primarily damages outer hair cells that are responsible for the sounds with high frequencies (3–6 kHz).

Ear canal performs like a resonator, turning up the sound. Ear canal resonance depends on its length. The shape and size of ear lobes and the curvature of ear canal affect frequency reactions of the eardrum. Different parts of the base membrane have different widths. High-frequency signals are affected by resonance near the oval window and low frequencies are affected near cochlea. Generally, from 16% to 24% of hearing loss in adults is due to the noise at working places. Human ear is more sensitive to high frequencies than to low frequencies, but people's sensitivity to higher frequencies decreases with age. Noise-induced hearing loss (NIHL) is the result of long-term exposure to noise that causes cumulative