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 damage to hair cells of the cochlea. It is bilateral and symmetrical, and it is usually affected by high frequencies (3, 4, and 6 kHz), and then extending to lower frequencies (0.5, 1, or 2 kHz). Hearing damage, as a result of confronting with noise for some years, is extended to both high and low frequencies. According to the Health and Human Services Ministry, when eliminating noise is not possible by engineering controls, proper use of hearing protection devices together with audiometric monitoring is effective in preventing NIHL. Effective hearing protection can be achieved by proper selection of different types of hearing aids, appropriate tests and compatibility, proper use, and continuous attention to their service.

Despite the fact that hearing system protection devices are not considered as the first protective action, they are regarded as a main measure for preventing hearing loss due to their low costs, availability, and effects. Popularization of the use of hearing protection devices prevents NIHL among workers who are exposed to excessive noise. Earplugs are one kind of hearing protection devices that are placed inside the ear to block the ear canal, and they are produced either in molds or by ductile foams. Inappropriate fitting of hearing protectors may have negative effect on noise reduction rate. The research results show that training in the appropriate use of earplugs significantly affects the efficacy of earplugs. The results of the study dealing with an analysis of noise damping rates by earplugs show that in low frequencies and high frequencies (8 and 12 kHz), earplugs have high rate of damping. The performances of hearing protection devices differ from each other in reducing and attenuating the noise. There are various methods for evaluating the performance of hearing protection devices in reducing noise. These methods are divided into subjective and objective aspects. Standard ISO4869–3:2007 suggests the acoustical test fixtures (ATFS). This is an objective method. In this method, hearing tests are done in different frequencies with or without the protective earphone. The attenuation index is obtained out of the difference between open and blocked ears' thresholds.

Hence, sound is one of the most important problems in industrial environment that contributes to hearing loss in the workforce. In addition, improper fitting of hearing protectors have negative effects on noise reduction. This experiment is done by simulating a model of ear canal and evaluating the rate of attenuation in different distances and different frequencies between the earplug and the microphone that is located in an ear as the simulator for receiving the sound, in different materials such as Teflon and cast iron. As a result, the effective frequencies that affect hearing loss and variations of the sound level in different frequencies and distances after placing the earplug are determined.

The results of sound simulation in octave frequency signals showed that there was a significant difference between the received noise by microphone before and after placing the earplug on the model ($P < 0.05$). The result showed that by increasing the frequency, the rates of sound reduction in different conditions had also an increasing trend. By increasing the frequency, the rate of attenuation on the used earplug also showed an increasing trend. By increasing the distance of the microphone from the earplug, the sound level had an increasing trend from the distance of 12.8 mm to 25.5 mm, but it had a decreasing trend at the distance of 31.1 mm. This decreasing trend was quite prominent in frequencies under 500 Hz. The sound level in Teflon showed increasing and decreasing trends for different frequencies at the distance of 25.5 mm, reaching to its maximum rate at the frequency of about 4000 Hz. The peak frequency of 4000 Hz was observed in most existing material states, including metal at the distance of 22.8 mm, Teflon at 17.5 mm, Teflon at 25.5 mm, and combination of metal and Teflon at 25.5 mm. Among different conditions the required level has reached its maximum value, that is, 59 dB, in the metal canal at the related distance of 22.8 mm and in the frequency of 4000 Hz (Fig. 1).

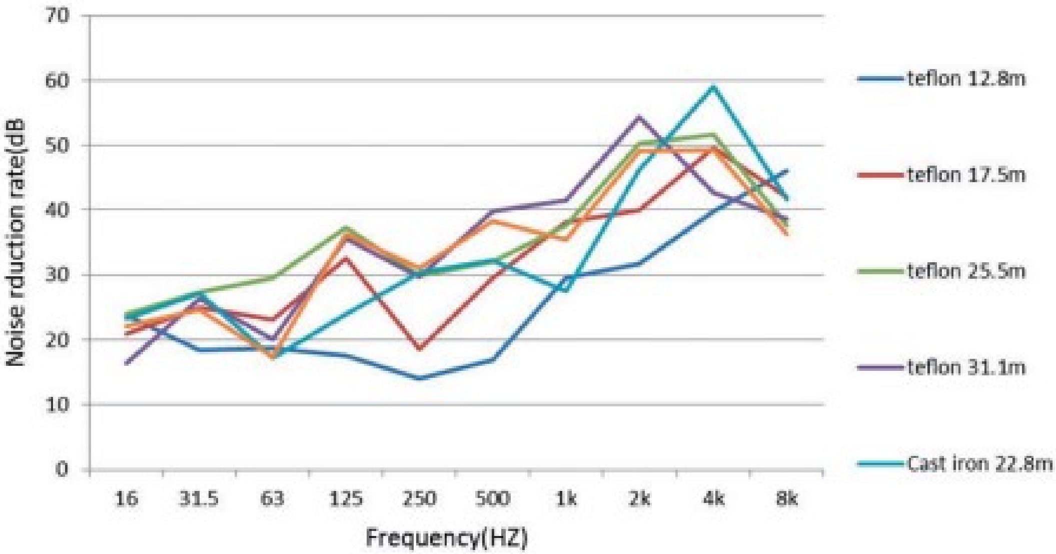

Fig. 1. Rate of sound attenuation (dB) in octave frequencies at different distances in simulated ear canal

As any object facing a sound, the ear acts as a passive filter. A passive filter is a low pass: the high frequencies are more absorbed by the object because high frequencies impose a higher pace of compression–decompression to the object. A contributing factor to this filter system is the contraction of the middle ear muscles which attenuate transmission of sound in the lower frequencies. Since sound level attenuations are different under different conditions at different distances of the simulated canal, the canal length can indicate the reason for the differences in related problems and harms in individuals. Results showed that as the distance between the earplug and the microphone increased, the sound increased up to a distance of 25.5 mm, and after this distance, the sound level had a decreasing trend, especially for frequencies under 500 Hz. The results of this study devoted to the analysis of the damping rate of earplug at different distances of its placement in the ear canal showed that when the distance of the earplug in the ear decreased, the rate of sound attenuation also decreased. This decrease was larger for the frequencies up to 1000 Hz and smaller in comparison with higher frequencies of 2000 Hz.

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STUDY OF WATER CONSUMPTION, POLLUTION, AND OTHER ANTHROPOGENIC INTERVENTIONS IN RIVER ECOSYSTEMS AND DEVELOPMENT OF CONSERVATION STRATEGIES

The study of water consumption, pollution, and other anthropogenic interventions in river ecosystems, as well as the development of strategies for their conservation, is of great importance. River ecosystems are a key element of the natural environment that determines not only the quality of life for humans but also for various plants and animal species. However, population growth, industrialization, and inefficient water use lead to serious anthropogenic interventions in river ecosystems, threatening their